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Routes to Lower Greenhouse Gas Emissions from Freight Transportation in the City of San José

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SJSU SAN JOSÉ STATE UNIVERSITY

MTI MINETA TRANSPORTATION INSTITUTE

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CSUTC California State University Transportation Consortium

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Report 22-47

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16. Abstract

Freight represents approximately 30% of all transportation-related emissions in the U.S., but local climate action plans (CAPs) and freight plans often place limited emphasis on freight emissions reduction strategies. The objective of this report is to examine and present strategies for the City of San José, California to reduce GHG emissions from freight. The authors conducted a geospatial analysis of freight data related to San José, and an analysis of relevant literature and successful freight reduction strategies implemented globally. The report also provides key objectives and generalized strategies to reduce GHG emissions from freight as well as specific recommendations for San José. The analysis and recommendations can guide future transportation planning within San José and help inform other municipalities seeking to reduce their own communitywide freight emissions.

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Contents

List of Figures

LIST OF TABLES

1. Introduction

Objective

The objective of this report is to help the City of San José develop and implement strategies to reduce greenhouse gas (GHG) emissions from freight transport. The report analyzes geospatial freight data, the relevant literature, and case studies. It also offers a description of common and innovative freight emissions reduction strategies, lessons learned from the development and implementation of such strategies in various communities, and recommendations for San José.

Problem Statement

Freight represents approximately 30% of transportation emissions, leads to significant quantities of air pollutants detrimental to human and environmental health, and accounts for 13% of all transportation-related fatalities in the United States.[1] With the significant and continued growth of e-commerce in recent years and especially as a result of the COVID-19 pandemic, many communities are concerned that these negative impacts will be exacerbated in the future.

Local and regional governmental agencies are exploring paths to establish a sustainable freight system through climate action plans (CAPs), freight plans, pilot projects, policies, regulations, and community and stakeholder engagement workshops. CAPs and freight plans can both outline strategies to mitigate GHG emissions and other air pollutants from goods movement and improve the efficiency of freight. CAPs are comprehensive roadmaps for measuring, tracking, and reducing GHG emissions from various sources, such as transportation. Because goods movement represents a significant part of transportation emissions, CAPs should not ignore freight emissions or strategies to address them. Freight plans include strategies to improve the transportation of inbound and outbound goods. Although freight plans often focus more generally on freight mobility, strategies to reduce GHG emissions are considered highly relevant. Freight emissions-reduction strategies can improve goods movement and offer other co-benefits, such as improving public health and safety. As part of their climate or freight planning processes, cities and regional governments are also exploring pilot programs to test the viability of specific strategies and emerging technologies, such as the use of sidewalk delivery robots for last-mile delivery.

Despite the significance of freight impacts on human and environmental health, research has shown a possible disconnect between local climate action planning and freight management efforts. For example, a recent study suggests that many local CAPs did not explicitly address freight transportation, and many freight plans did not directly focus on strategies to reduce freight emissions in the past decade.[2] With the availability of locational "Big Data" (i.e., navigation-GPS data and Location-Based Services (LBS) data), the growth of e-commerce, and subsequent freight impacts, we anticipate that the new generation of CAPs and freight plans will need to focus more on freight's negative environmental impacts and their distribution on various communities.

The City of San José's Freight-Planning Efforts

It is critical for San José to proactively plan for an effective, efficient, green, and equitable freight system as the transportation sector is responsible for a significant portion of overall GHG emissions and air pollution in the city. In 2019, transportation accounted for 51.1% of total GHG emissions in the city.[3] Urban freight transportation constitutes a major component of the transportation sector, especially given the high demand for freight services in urban areas. This demand, which is expected to grow in the future, is driven by population growth and increasing e-commerce. Freight emissions impacts are not equally distributed across the city; communities situated along major transportation corridors and/or freight hubs are disproportionally burdened. Also, low-income communities of color often suffer from a mix of economic, health, and environmental burdens[4] that make them more vulnerable to adverse consequences from freight.

The City of San José has begun working to reduce freight emissions with the support of the Delivering Zero Emission Communities (DZEC) program, which aims to reduce freight emissions and the disproportionate impacts of freight on vulnerable and low-income communities.

Organization of the Report

This report is organized into three main sections. The first offers a geospatial analysis of freight data. Understanding where freight emissions are coming from and how freight is distributed across the city is the first step towards developing a plan to address freight emissions. The second section summarizes and synthesizes the main findings from the analysis of the literature on freight emissions reduction strategies. It also showcases several case studies illustrating innovative and/or common strategies that cities across the globe have taken to build a green freight system. The last section provides a set of important objectives, key strategies, and policy recommendations for San José to consider in their freight planning efforts.

2. Background

With the growth of urban freight transportation in urban areas and the emergence of San José as a prominent hub in the global supply chain, as noted, the transportation sector produces a significant portion of GHG emissions and air pollution in the city (in 2019, over 50%). Unfortunately, freight vehicles are predominately powered by fossil fuels, such as diesel and gasoline, which are primary contributors of not only GHGs but also criteria pollutants. This pollution has significant adverse impacts on communities that are situated along major transportation corridors (freeways) and freight distribution hubs. Often these communities are composed of low-income racial and ethnic minorities and suffer "from a combination of economic, health, and environmental burdens."[5]

This section provides background information on freight transportation in San José and its associated impacts. More specifically, this section focuses on freight emissions, freight travel patterns, and freight crash data.

Methodology

Freight data from various sources were collected and represented in a geospatial format using ArcGIS. This representation helped in understanding the spatial distribution of freight infrastructure and its associated activities in San José. Table 1 depicts the different types of data used for this study.

Table 1. Datasets Used for Freight Data Analysis

Data	Data Source	Description
Primary Truck routes	Envision San José 2040 (General Plan)	A PDF map of the primary truck routes in San José was georeferenced in ArcGIS Pro to visualize the likely travel patterns of freight within San José.
Crash Data	City of San José Open Data Portal	This is a public record of every vehicle-related crash on record in San José. The data were filtered to isolate crashes involving freight vehicles that have occurred since 2017. Additionally, these data were further filtered to identify which of these crashes resulted in an injury (minor, moderate, severe, fatal).
Freight Trip origination/ destination	City of San José	Contains data on origin and destination patterns of freight vehicles at the census tract level in San José for the years 2019, 2020, and 2021. This is represented as the Average Traffic count per day (known as Average Daily Traffic) for trip origination (Trip Starts) and trip destinations (Trip Ends) for each census tract. It also has time-based data on trip origination and destination with respect to day of the week and time of day.
Freight vehicle specifications	CALSTART	These data provide the DMV records for all vehicles qualifying as freight vehicles in San José, enabling the research team to categorize by vehicle type, vehicle use, and fuel type.
Freight emission data	Emission Factor (EMFAC)	This provides information on the total emissions of freight vehicles in Santa Clara County. This study was concerned with only CO2, CH4, and N20 emissions which were then adjusted to the CO2 equivalent value according to the relevant AR6 value.
Equity Priority Communities	Metropolitan Transportation Commission (MTC)	These data were used to visualize areas with high numbers of underserved households defined as low-income, people of color, and limited English proficiency, among other factors. These data are organized at the census tract level and concern levels are categorized as "high," "higher," and "highest."

These data were used to create different layers of geospatial information using ArcGIS, which were then analyzed in conjunction with each other in order to draw conclusions on various aspects of freight transportation in San José. The main areas of analysis:

(i) Freight characteristics: This pertains to attributes of freight vehicles that operate in San José. This includes vehicle typology, their predominant usage, fuel source, and their contribution to GHG emissions in San José.

(ii) Freight distribution: This aspect primarily covers the distribution of freight activity (spatial and temporal distribution of freight trips) and infrastructure (such as distribution centers and truck routes) in San José.

(iii) Freight Trends: This involves the study of freight activity levels in the past years (2019–21) to better understand freight trends in San José.

(iv) Freight Crashes: This aspect focuses on comprehending the contribution of freight transportation toward road collisions. This was done by mapping the locations of crashes involving freight vehicles over the past five years and recording their corresponding injury levels.

Findings

Freight Characteristics

1. Vehicle types

Table 2. Distribution of Freight Vehicles as Per Class Type

Vehicle Class Type*	Count	Percentage
2	2,337	12.77%
3	5,121	27.98%
4	2,714	14.83%
5	1,662	9.08%
6	2,275	12.43%
7	1,149	6.28%
8	3,043	16.63%
Total	18,301	100.00%

* 2 = light duty, 3 & 4 = medium duty, 5 & 6 = light heavy duty, 7 & 8 = heavy duty

As can be seen from Table 2, vehicle types are spread evenly across all registered freight vehicles in San José. Medium-duty vehicles account for the most freight registrations at 42.81%.

2. Primary usage

Freight vehicles are used for a wide variety of purposes in San José as shown in Table 3 with their related percentages. Individual uses represent the largest category of freight vehicle uses at 45.08%.

General freight accounts for 5.36% of vehicles. Other high percentages include construction at 9.11% and services at 8.77%.

Table 3. Freight Vehicle Usage

Vehicle Uses	Percentage of Uses	Count of Uses
INDIVIDUAL	45.08%	8,250
CONSTRUCTION	9.11%	1,668
SERVICES	8.77%	1,605
GENERAL FREIGHT	5.36%	981
WHOLESALE/RETAIL	4.80%	878
LEASE/RENTAL	4.58%	838
UNCLASSIFIED	4.48%	819
MANUFACTURING	3.01%	550
FOOD PROCESSING & DISTRIBUTION	2.13%	389
SANITATION/REFUSE	1.91%	350
LEASE/FINANCE	1.64%	301
LANDSCAPING/HORTICULTURE	1.50%	275
GOVERNMENT/MISCELLANEOUS	1.37%	250
UTILITY SERVICES	1.36%	249
PETROLEUM	0.71%	130
DEALER	0.68%	124
BEVERAGE PROCESSING & DISTRIBUTION	0.55%	101
FORESTRY/LUMBER PRODUCTS	0.49%	90
MOVING AND STORAGE	0.49%	90
LEASE/MANUFACTURER SPONSORED	0.48%	88
AGRICULTURE/FARM	0.47%	86
BUS TRANSPORTATION	0.28%	51
SPECIALIZED/HEAVY HAULING	0.22%	40
ROAD/HIGHWAY MAINTENANCE	0.19%	35
MISCELLANEOUS	0.14%	26
GENERAL FREIGHT/HAZARDOUS MATERIALS	0.12%	22
SANITATION/HAZARDOUS MATERIAL	0.03%	5
EMERGENCY VEHICLES	0.02%	3
HAZARDOUS MATERIALS	0.02%	4
MINING/QUARRING	0.01%	1
PETROLEUM/HAZARDOUS MATERIAL	0.01%	1
VEHICLE TRANSPORTER	0.01%	1
Grand Total	**100.00%**	**18,301**

3. Fuel Sources

Using information from DMV registrations within the CALSTART dataset, Table 4 displays the breakdown of fuel consumption among freight vehicles registered in San José. Diesel fuel accounts for the majority at 64.79%.

Table 4. Distribution of Freight Vehicles as Per Fuel Type in San José

Freight Vehicle Fuel Types	Percentage of Primary Fuel Type Usage Among San José Freight Vehicles
Compressed Natural Gas	0.17%
Convertible	0.07%
Diesel	64.79%
Electric	0.01%
Electric and Diesel Hybrid	0.11%
Flexible	1.11%
Gas	33.56%
Propane	0.05%
Unknown	0.11%

4. GHG emissions

Total GHG emissions produced by freight vehicle movements in Santa Clara County and the City of San José were calculated using EMFAC data sets. EMFAC offers county-level emissions data to assess emissions from on-road vehicles. Table 5 represents this calculation using the 2021 Emission Factor data; these numbers have been adjusted to their CO2 equivalent. An estimate of total GHG emissions from freight in 2021 in San José was calculated by multiplying per capita emissions in Santa Clara County by San José's population.

Table 5. Total GHG Emissions from Freight Vehicles In 2021 in Santa Clara County and San José

	Total CO2 Emissions	Total CH4 Emissions	Total NO2 Emissions
Santa Clara County	6499472.72 CO2e	10078.96 CO2e	98091.04 CO2e
City of San José	3420775.12 CO2e	5304.72 CO2e	51626.86 CO2e

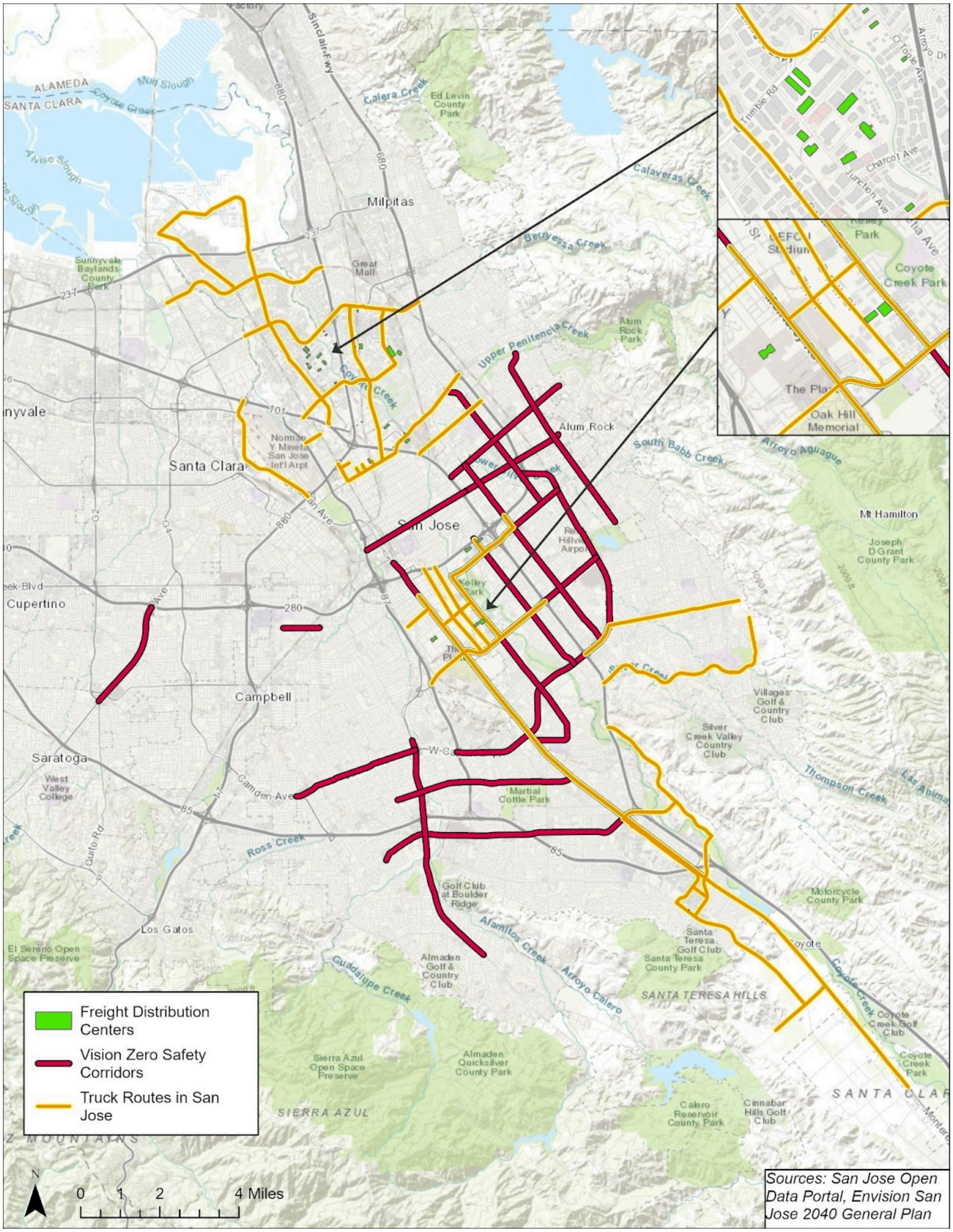
*All rates have been adjusted to their CO2-equivalent value according to the relevant AR6 value.

Freight Distribution

1. Freight Distribution Centers

The locations of San José's 31 largest freight distribution centers were mapped using ArcGIS Pro from data provided by the City of San José. These centers were identified through an online search. The distribution centers are primarily clustered in two locations: directly north and south of downtown San José. They align with the intended freight routes set forth by the Envision San José 2040 General Plan and match the noted hot spots for freight trip origin and destination points.

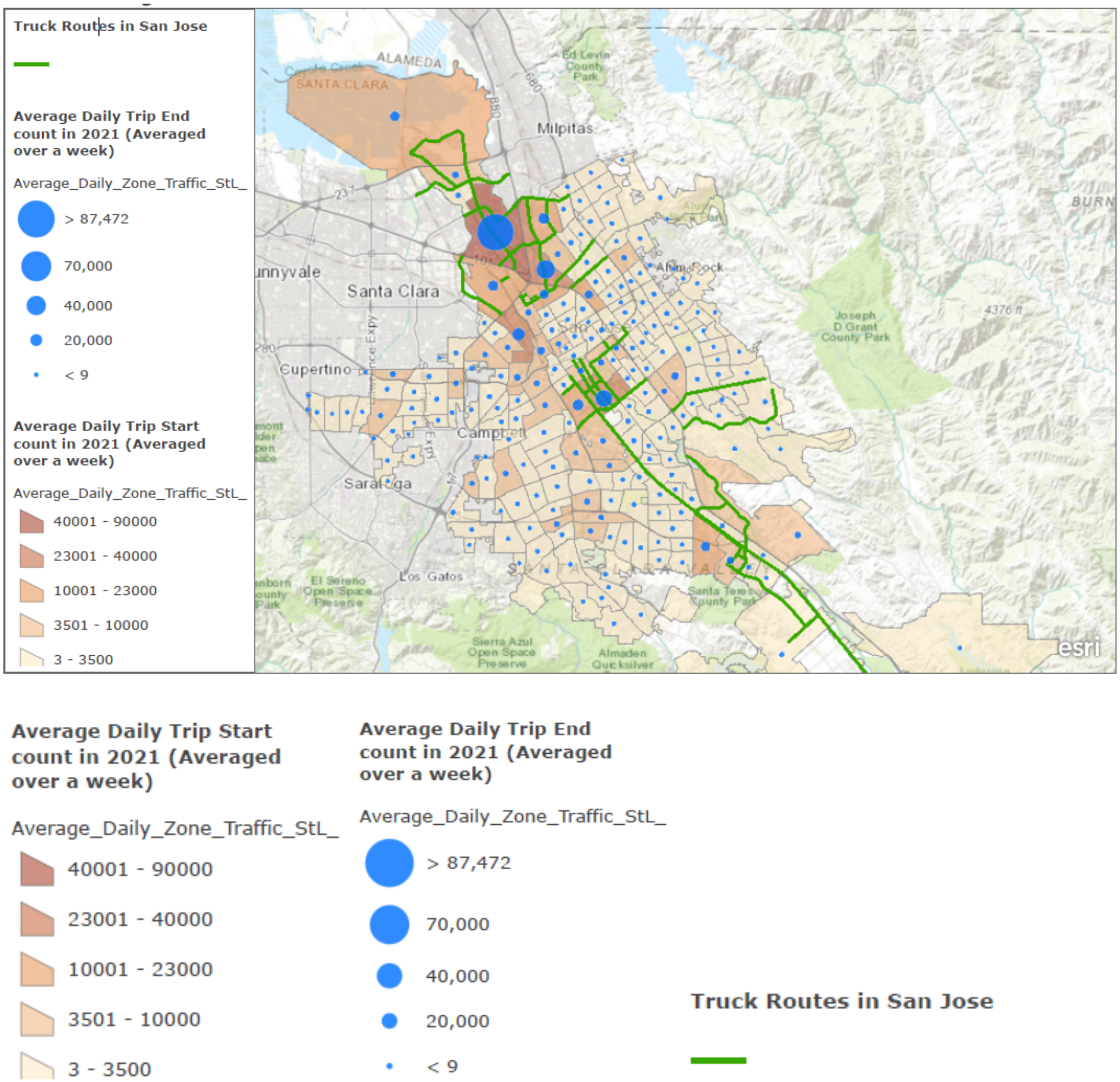
Figure 1. Freight Infrastructure Map



2. Spatial Distribution of Freight Trip Origination and Destination

To identify zones with high levels of freight activities, freight traffic (in terms of trip origination and destination) was mapped at the census-tract level. Figure 2 illustrates the Daily Trip counts for Trip Starts and Trip Ends (averaged for a week) in 2021 for San José in conjunction with primary truck routes in the city. The darker areas and larger circles represent census tracts with high levels of freight activity. There are two particular areas—one in the north San José (near the airport) and another in central San José (near Downtown)—that experience high freight traffic. Truck routes in the city are also mostly concentrated within these areas, which further corroborates the findings from freight traffic data and shows that freight trucks are utilizing truck routes.

Figure 2. Spatial Distribution of freight trips (Weekly Average Daily Trip counts of Origination and Destination)

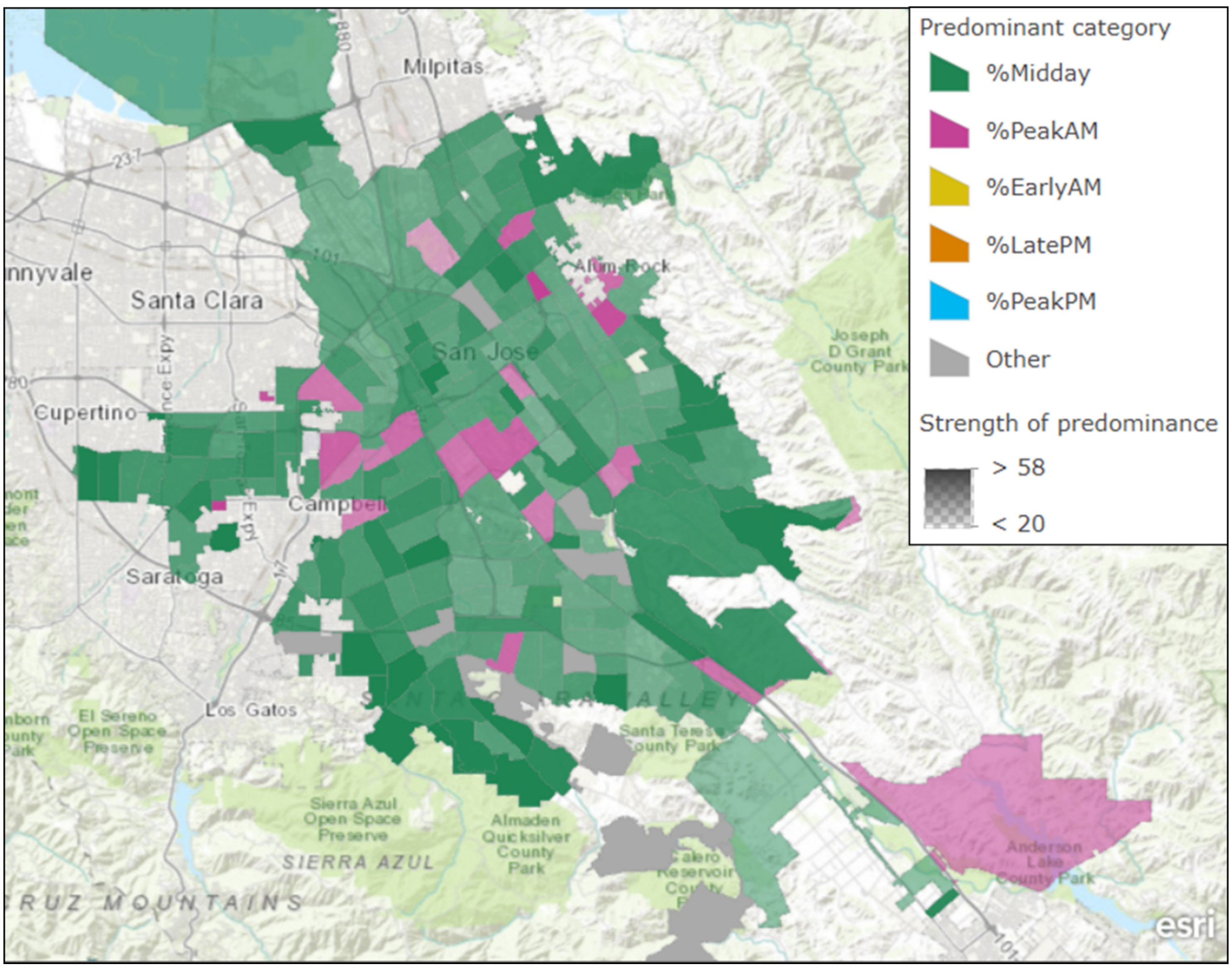


3. Time Distribution of Freight Trips

The study of freight trip data (as per time of day) helped identify the time periods of high/low freight activity. A 24-hour time period is divided into (i) Early AM (12 a.m.–6 a.m.), (ii) Peak AM (6 a.m.–10 a.m.), (iii) Midday (10 a.m.–3 p.m.), (iv) Peak PM (3 p.m.–7 p.m.) and (v) Late Night (7 p.m.–12 a.m.). Figure 3 depicts the distribution of freight activity in terms of trip origination during each of these time periods on a weekday for all census tracts in San José. The map color codes each census tract based on the predominant time freight activity occurs. Thus, it is evident that the majority of San José's census tracts experience most freight activity during Midday (as shown by the predominant green color).

It should also be noted that the mapping was done for trips (both origination and destination) on weekdays and weekends. The result was the same with high levels of freight activity occurring during the afternoon.

Figure 3. Temporal Distribution of Freight Trip Over a Weekday (Average Weekday Trip Counts of Origination and Destination) in 2021

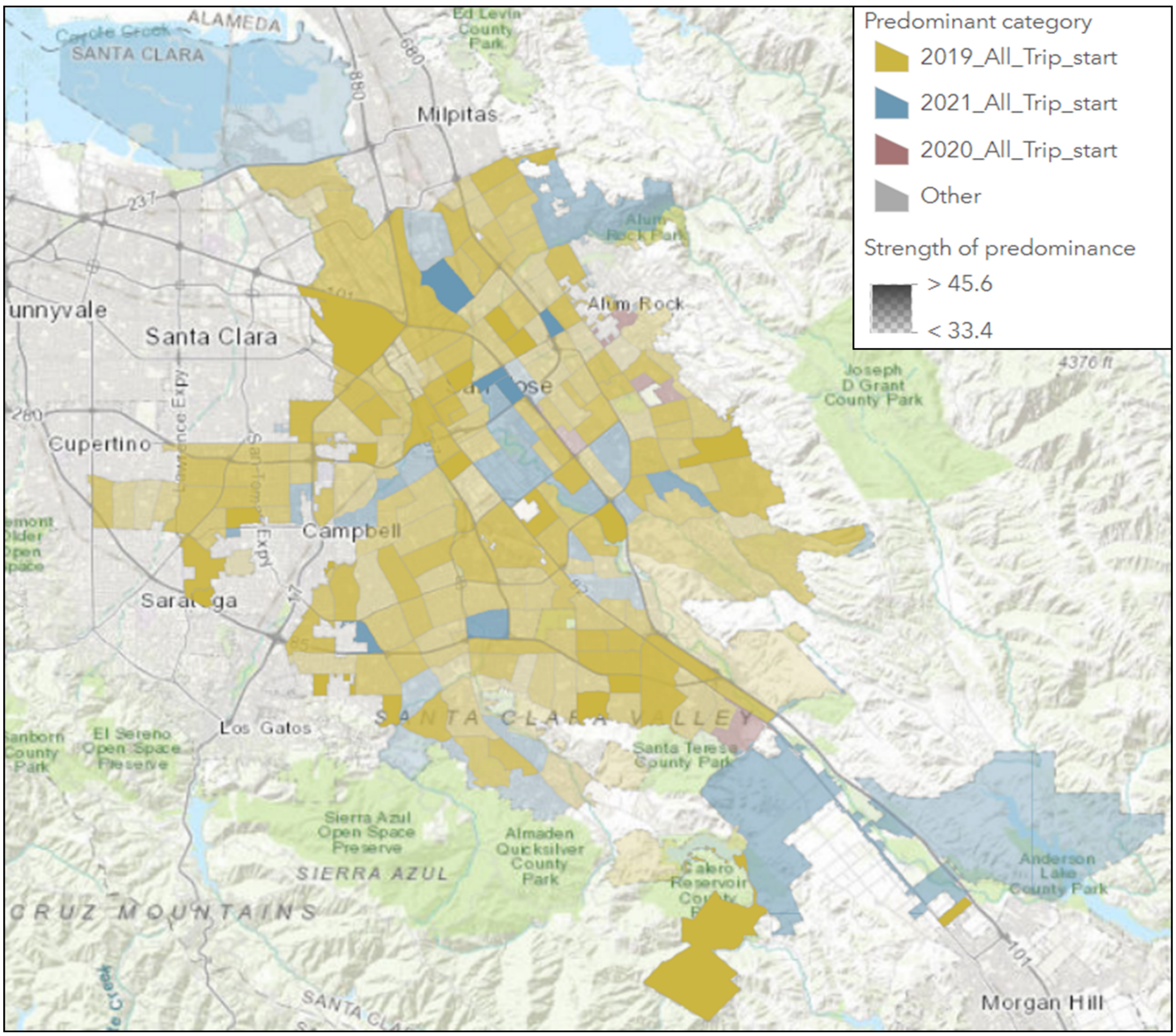


Freight Trends

1. Transportation Trends from 2019–2021

Freight activity, in terms of total freight trips generated, for 2019, 2020, and 2021 were mapped in order to understand trends in freight movement. Figure 4 highlights census tracts in San José based on the year it experienced its highest freight activity. This map shows that the majority of areas in San José recorded high freight movements during 2019 (in yellow). Only a few census tracts show higher freight activity in 2021 and 2020. However, it should be noted that freight operations in 2021 were higher than that of 2020. This indicates a trend wherein logistic activities are recovering from the aftermath of the COVID-19 pandemic. It should also be noted that the same trends were observed when mapping freight trip destination.

Figure 4. Freight Trends for 2019, 2020, and 2021 in San José

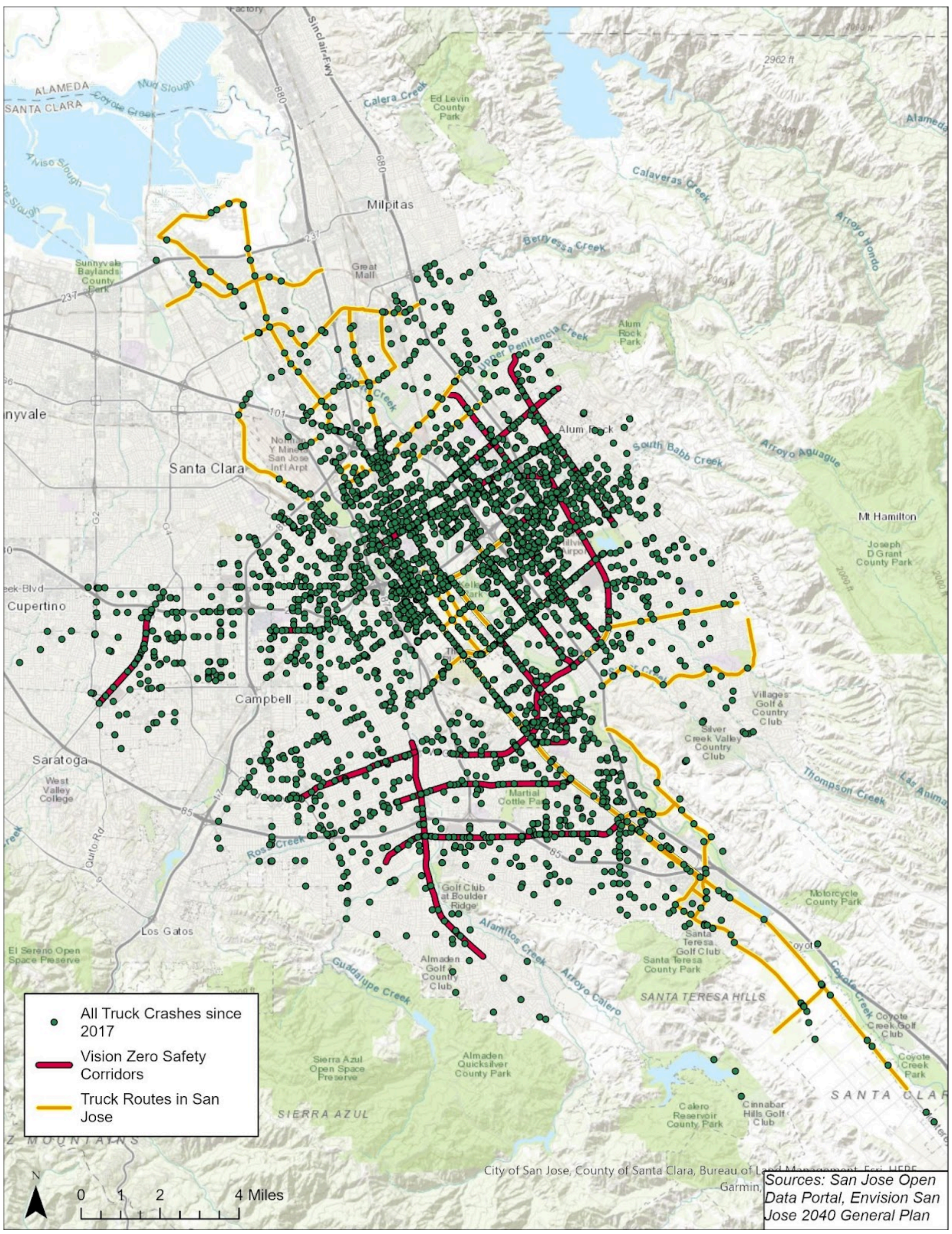


Freight Crashes

1. Locations

Crash data provided from the City of San José Open Data Portal was used to visualize all crashes in the city where freight was involved in the last five years. Said crash data were then referenced to both the City of San José Vision Zero Priority Safety Corridors (PSCs) and the Envision San José 2040 General Plan designated truck routes. As the map in Figure 5 shows, freight crashes are primarily concentrated in San José's central and downtown areas.

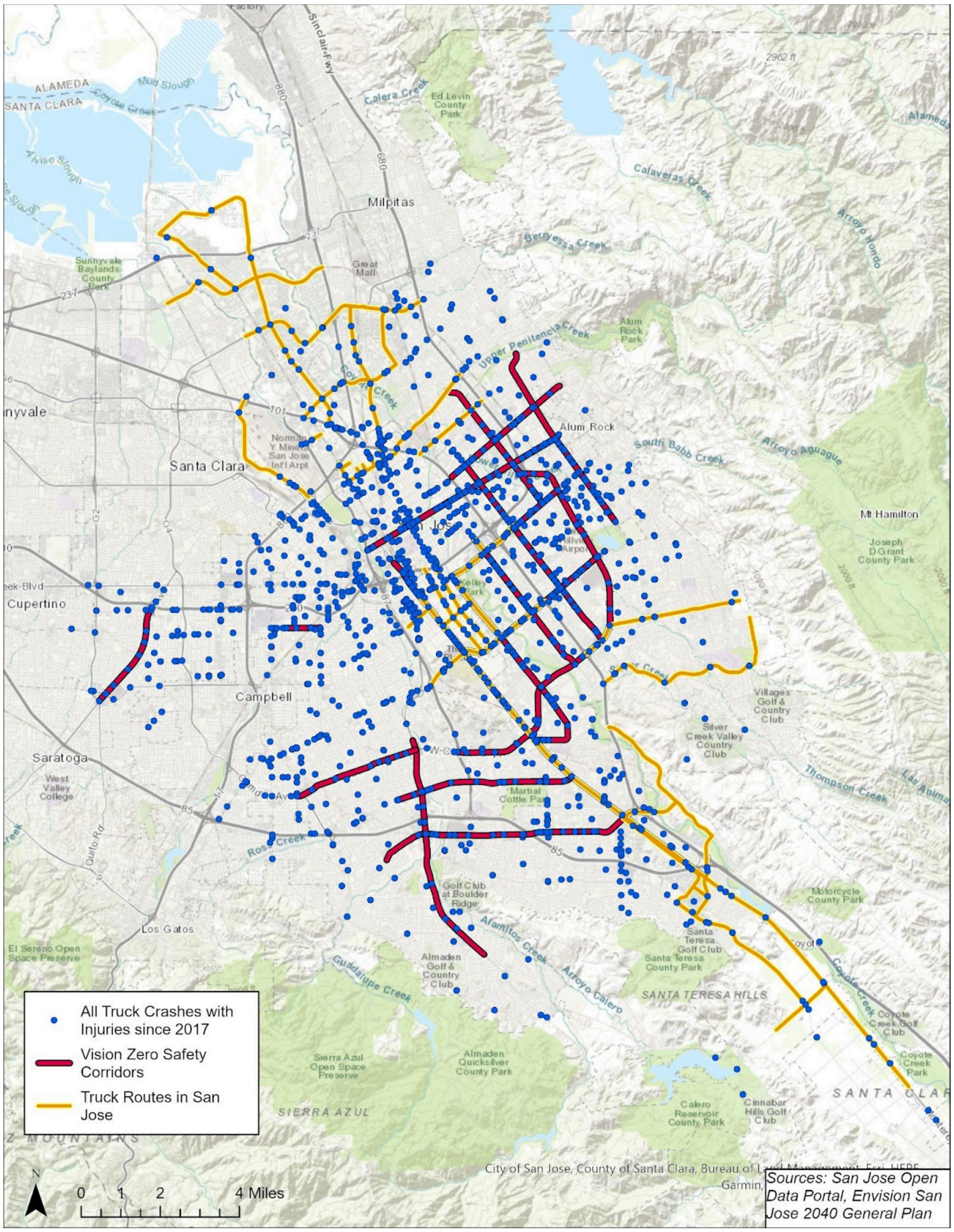
Figure 5. Location of Crashes Involving Freight Vehicles in San José



2. Level of Injury

These data were further refined to show all aforementioned freight-related crashes that caused injury. The resulting map is displayed below. Many of the crashes occurred within the Vision Zero PSCs. However, large portions of the designated truck routes have minimal crashes.

Figure 6. Location Of Freight Vehicle Crashes With Injuries



3. Freight Strategies and Case Studies

This section summarizes key findings from an analysis of existing literature as well as current best practices in freight-emission reduction. Specific strategies are identified and case studies for each strategy are provided to give an example of implementation as well as major takeaways and lessons learned. Case studies were collected from both domestic and international cities.

Climate Action Plans (CAPs) and Freight Plans

Climate action plans (CAPs) and freight plans can both outline strategies to mitigate GHG emissions from goods movement and improve the efficiency of freight. CAPs are comprehensive roadmaps for measuring, tracking, and reducing GHG emissions from various sources, such as transportation. Because freight represents approximately 30% of transportation emissions in the U.S.,[6] CAPs should not ignore freight emissions or strategies to address them. Freight plans include strategies to improve the transportation of inbound and outbound goods. Although freight plans often focus more generally on freight mobility, strategies to reduce GHG emissions are considered highly relevant. Freight-emission reduction strategies can improve goods movement and offer other co-benefits, such as improving public health and safety.

Despite the significance of freight emissions, research has shown a disconnect between CAPs and freight plans in many cities: Many CAPs do not explicitly address freight transportation, and many freight plans do not directly focus on strategies to reduce freight emissions in the past decade.[7] With the availability of locational "Big Data" (i.e. navigation-GPS data and Location-Based Services (LBS) data) and the growth of e-commerce, we anticipate that the new generation of CAPs and freight plans will focus more on freight emissions.

Case Study: City of Seattle's CAP and Freight Master Plan

In 2013, the city of Seattle adopted a CAP to reduce GHG emissions from road transportation, energy, and waste, and to help build vibrant, prosperous, and equitable communities. As of 2008, road transportation accounts for 40% of total emissions: 18% attributed to freight and 22% to passenger movement. Non-road transportation, which involves both freight and passenger movement, accounts for an additional 22% of total emissions. Although Seattle's CAP stresses the importance of freight emissions, it also indicates that freight is not the plan's focus as the city has little influence on vehicle fuel and technology improvements (i.e., two key strategies to reduce freight emissions). The CAP views freight-emissions reduction as a co-benefit of other transportation strategies that reduce congestion and improve the movement of goods across the city.

Nonetheless, Seattle's CAP took a big step to help address freight emissions by recommending the city to develop a multimodal Freight Master Plan (FMP) that includes GHG emissions-reduction goals in addition to freight-efficiency goals. In 2016, the Seattle Department of Transportation adopted an FMP organized around six goals: economy, safety, mobility, state of good repair, equity, and environment. The plan discusses several strategies that improve goods movement in Seattle, but also generate environmental co-benefits. For example, the FMP mentions the importance of supporting alternative freight modes, such as bicycle delivery, as well as eliminating bottlenecks and vehicle idling. The Seattle FMP also highlights opportunities to both improve freight movement efficiency while also realizing environmental benefits.

Source: "Seattle Climate Action Plan" (City of Seattle, April 22, 2013), https://www.seattle.gov/documents/Departments/Environment/ClimateChange/2013_CAP_20130612.pdf; "City of Seattle Freight Master Plan" (Seattle Department of Transportation, September 2016), https://www.seattle.gov/documents/Departments/SDOT/About/DocumentLibrary/FMP_Report_2016E.pdf.

Case Study: Denver's Regional Multimodal Freight Plan

Denver Regional Council of Governments developed a Regional Multimodal Freight Plan (MFP) in 2020 that provides a strategic view of key freight challenges and opportunities that communities within the region should consider. The plan also offers a set of strategies to help improve regional data, integrate freight considerations into other types of plans, coordinate with industry partners, and encourage the development of local freight master plans.

Although emissions reduction is not one of the MFP's main goals, the plan mentions sustainability as a key challenge. To address this challenge, the MFP recommends developing shared initiatives between the public and private sectors. Stakeholders involved in the planning process raised several issues that require further investigation: the possibility of using electric or alternative fuel delivery vehicles; new delivery modes and consumer awareness programs to address residential freight delivery challenges; programs to encourage commercial fleet fuel-efficiency upgrades; moving more freight by railroad; and harmonizing freight distribution patterns and needs with land-use planning and development decisions.

One of the strengths of Denver's MFP is its focus on the spatial patterns of freight distribution, challenges, and opportunities. For example, the plan identifies assets, needs and issues, and context-sensitive strategies and actions for each freight focus area in the region. Understanding freight's geospatial patterns and how it impacts various communities is a key step for the development of appropriate strategies to improve freight movement.

Source: "Regional Multimodal Freight Plan" (Denver Regional Council of Governments, 2019), https://drcog.org/sites/default/files/regional_multimodal_freight_plan.pdf.

Case Study: 2021 Los Angeles (LA) County Goods Movement Strategic Plan

In 2021, in response to challenges faced by the L.A. County to be economically competitive, environmentally sustainable, and socially equitable, L.A. Metro developed a Goods Movement Strategic Plan. The plan discusses five key initiatives and multiple strategies to improve freight movement across the region. The five key initiatives included: (1) equity for goods movement; (2) an L.A. Metro countywide clean truck initiative to accelerate the deployment of near zero and zero emissions freight vehicles; (3) Southern California rail investment partnership; (4) urban freight delivery; and (5) logistics workforce and competency. The urban freight delivery initiative focuses on urban freight delivery and curbside-demand management challenges and opportunities. Three out of th

e five strategies in the urban freight initiative focus on curb issues and related action items, such as curbside demand management and equity considerations, establishing a curbside mobility policy platform, and serving as a clearinghouse for curbside asset inventory.

L.A. County's goods movement strategic plan acknowledges past transportation and land use wrongdoings that contributed to racial inequity and examines COVID-19's impacts on goods movement. It also stresses the importance of addressing all negative impacts from freight, such as economic disparities, air quality impacts on L.A. residents and particularly disadvantaged communities, and traffic and safety impacts.

Source: "L.A. County Goods Movement Strategic Plan" (L.A. Metro, 2021), https://media.metro.net/2021/Goods-Movement-Strategic-Plan-Spreads.pdf.

Case Study: West Oakland Truck Management Plan

The West Oakland Truck Management Plan (TMP) was adopted in 2019 to mitigate the negative impacts of freight trucks on local streets in West Oakland. The main goals of the TMP are to improve safety for people walking, biking, and driving in West Oakland; improve quality of life; ensure compliance with the city's parking restrictions, and reduce localized diesel emissions. The TMP was developed by the Port of Oakland and the City of Oakland with input from West Oakland residential and business communities. The community engagement process included a series of workshops, one-on-one meetings with stakeholders, presentations before business and community associations, and surveys. The TMP includes ten strategies to improve truck routing, address truck parking issues, and improve safety of pedestrians and bicyclists. Although the TMP does not explicitly focus on GHG emissions reduction, some of the recommended strategies will also produce emissions-reduction co-benefits. The West Oakland TMP offers a good example of an action-based plan developed through a collaborative process with key stakeholders. The TMP is also unique since it was designed to address a specific problem related to freight vehicles, which disproportionately impacted low-income and minority communities. The West Oakland TMP highlights the importance of environmental justice in freight planning.

Source: "West Oakland Truck Management Plan" (City of Oakland, May 2019), https://cao-94612.s3.amazonaws.com/documents/West-Oakland-Truck-Management-Plan-FINAL-APPROVED.pdf.

Land-Use Policy and Urban Form

Land use policy and urban form are central to freight emissions reduction planning. The success of many of the strategies presented in this report heavily depend on land use and urban form. For example, cargo-bikes and delivery robots are more effective for shorter travel distances created by a more compact urban form. Also, research has shown that freight emissions scale linearly with overall transportation emissions: as total transportation emissions increase or decrease, there is a proportional change in freight emissions.[8] In other words, any policies that successfully reduce overall transportation emissions are highly likely to proportionally reduce freight emissions. As such, freight emissions reduction planning should be harmonized with other vehicle miles traveled (VMT) mitigation strategies and land use planning processes.

The concept of freight-efficient land use stresses the importance of considering freight impacts when making land use decisions. For example, the common practice of moving land uses considered incompatible with the rest of urban activities to special districts or the outskirts of urban areas can create sprawled supply chains, and thereby increased delivery distances. The main principles of freight-efficient land use planning include: 1) minimizing social and environmental costs associated with freight and avoiding focusing on freight's private costs only; 2) reducing distance traveled at various supply chain stages by creating compact supply chains to the extent possible such as by preserving urban warehouses; 3) mitigating externalities associated with supply chains, such as traffic congestion; 4) recognizing and accounting for local conditions; and 5) engaging the community and various stakeholders.[9] The freight strategies explored further in the following sections (e.g. urban distribution centers, neighborhood microhubs, and last-mile delivery solutions) are meant to help put these guiding principles into practice.

Case Study: The Port of New York's Relocation

One of the best-case studies to highlight the significance of land-use decisions on the entire supply chain is the Port of New York's relocation. In the early-20th century, the Port of New York fostered the growth of New York City's (NYC) industrial sector with many manufacturers agglomerating around the waterfront for easy access to shippers. By 1950, maritime activities shifted to the Port of Newark (New Jersey), which required transporting cargo across the Hudson River. Over time, as the population of NYC increased and its economy shifted from primarily manufacturing to service-oriented industries, the demand for freight activity increased. Because a large portion of freight transported to NYC arrives at New Jersey and even Pennsylvania, NYC incurs billions of dollars in congestion costs. A proposal to build a freight tunnel across the Hudson River to directly bring rail freight to NYC is estimated to cost between $7 and $11 billion. Even though the community and stakeholders welcomed the relocation of the Port of New York at that time, it is unlikely that policymakers could have predicted the economic and environmental impacts of massive cargo transport across congested river crossing. Some researchers have argued that retaining a part of the port activity on the NYC-side could have alleviated the tremendous externalities caused by the relocation of the Port of New York. One important lesson applicable to all cities (not just port cities) is that the relocation of massive traffic generators should be carefully examined. The relocation of the Port of New York demonstrates the importance of land use policy in urban freight. Specifically, this case study highlights the externalities associated with supply chains.

Source: Jose Holguin-Veras et al., "Freight-Efficient Land Uses: Methodology, Strategies, and Tools," *Sustainability* 13, no. 6 (2021), https://doi.org/10.3390/su13063059.

Urban Distribution Centers

An urban distribution center (UDC) is a facility for the storage and shipping of goods directed to or from urban areas. The main goals of UDCs can be synthesized into improving efficiency, environmental sustainability, and livability. A detailed analysis of more than 60 case studies in Europe, Japan, and the U.S. showed that UDCs often pursue a combination of the following strategies: (1) mitigating road freight traffic by centralizing deliveries; (2) changing the type of delivery vehicles used; (3) reducing the negative environmental impacts of goods delivery activity by making deliveries more efficient; (4) enhancing the efficiency of urban freight operations; and (5) improving turnover by reducing the need for goods storage at urban premises.[10] Typically, UDCs help consolidate deliveries, and by extension, increase efficiency in the distribution process and reduce congestion and emissions. UDCs have been implemented to some success in several urban areas internationally.[11]

Despite the popularity of UDCs as a key part of city logistics, lessons learned from numerous case studies indicate that these centers should not be viewed as a panacea for freight delivery problems. There are many factors to consider for building and operating an effective and efficient UDC, such as but not limited to its location, market coverage and services provided, partnership requirements with freight carriers, types of delivery vehicles used, and the needs of the community. An analysis of UDCs in European cities shows that failed attempts to establish a successful distribution hub had some common mistakes, such as: (1) establishing a distribution hub based on inaccurate data (e.g., how freight delivery is distributed across the city; what industries depend on freight delivery systems within the city, etc.); (2) ignoring the needs of the community (e.g., increasing delivery times when the community expects faster delivery); (3) increasing the cost for product shippers due to an ill-conceived design (e.g., UDC location was inappropriate); (4) developing a flawed revenue model, which resulted in the need for heavily subsidizing the UDC ; and (5) relying on elusive political support.[12]

Many of the other urban freight emission strategies presented in this report complement UDCs. For example, La Petite Reine in Paris, uses cargo bikes to distribute parcels within the city center.[13] UDC's can serve as a hub in a "hub and spoke"-style supply chain with the final deliveries conducted by lower-intensity vehicles such as cargo bikes, autonomous delivery robots, or light-duty trucks.

Case Study: La Petite Reine in Paris

La Petite Reine (LPR) began operation in 2001 with only a few electrically assisted bicycle deliveries per day in central Paris, but it has since expanded to one million deliveries per year in the entire city. This privately-run urban distribution center has been successful for a few key reasons. Most importantly, LRP has benefitted from the city's freight strategy or "Plan de Déplacement de Paris," which promotes modal shift by banning large trucks from entering central Paris and limiting access by smaller trucks to only certain hours of the day. Because the European Union classifies cargo bikes as bicycles, LPR has an advantage in its increased access to certain restricted areas, such as pedestrian zones and the urban core. Second, cargo bikes are allowed to park almost anywhere in the city, making it easier to navigate through congestion. Because of these advantages, LPR has offered a cost-effective freight delivery system, which also offers fuel savings of approximately 90 tons of oil equivalent and associated emissions annually.

Case Study: Tenjin Joint Distribution System in Fukuoka, Japan

The Tenjin Joint Distribution System (TJDS) located in Fukuoka, Japan is perhaps the longest running UDC in the world, being in operation since 1978. The TJDS began when 30 freight carriers collaborated to create a joint distribution system to address delivery costs and the difficulty of moving through congested streets. The TJDS was ultimately successful in removing vehicles from the street and lowering freight vehicle miles traveled. However, recent trends have led to a decline of the TJDS including a withdrawal of public subsidies and support, a failure to adopt and adapt to new technologies (e.g., not having a website or email service), and government interventions that have added parking spaces for trucks that reduce the TJDS's competitive edge. The 30-year success and then subsequent decline of the TJDS points to the need for ongoing government policies that support UDC's in order for them to remain competitive and for UDCs to actively engage with and adopt innovative strategies and technologies to better serve freight clients.

Source: Marta Panero, Hyeon-Schic Shin, and Daniel Polo Lopez, "Urban Distribution Centers – A Means to Reducing Freight Vehicle Miles Traveled" (NYU Rudin Center for Transportation Policy and Management, February 2011), https://wagner.nyu.edu/files/faculty/publications/NYSERDA20UDCs20Final20Report202011-201.pdf.

Neighborhood Microhubs

A neighborhood microhub is a central location for pick up and drop off of goods for residents and businesses in a surrounding neighborhood. It aims to reduce delivery emissions as well as congestion in an urban area by consolidating trips and avoiding freight vehicles traveling into urban centers with partial loads. In this way, they can be considered an evolution of the UDC, which have often been unsuccessful due to issues with coordinating interested parties and difficulties with locating large UDCs near relevant delivery areas.14 In comparison to UDCs, a microhub is located closer to the delivery area and has a more limited spatial range. They also facilitate a mode-shift to low-emission or soft transportation modes, such as walking or cargo bikes for the final last-mile delivery,15 especially due to the smaller delivery area when compared to UDCs. Microhubs can reduce emissions by fostering the use of environmentally friendly vehicles such as light-duty electric vehicles or bikes.16 Additionally, research shows that vehicle miles traveled from freight is reduced in areas with microhub facilities, while increasing efficiency for freight companies.17

Case Study: Neighborhood Delivery Hub in Seattle's Uptown

In 2021, the City of Seattle partnered with the University of Washington Urban Freight Lab as well as other mobility operators and delivery companies to create a neighborhood delivery hub in Seattle's dense Uptown Neighborhood. Located in an underutilized surface parking lot, it consolidates several delivery related services for the nearby residents. Services include common carrier lockers to allow customers to complete the last mile of their delivery on their own, an electric-assist cargo bike fleet to complete last mile deliveries, and a neighborhood kitchen to facilitate food preparation for mobile application delivery orders. Researchers from the University of Washington monitored the microhub and analyzed its effectiveness. Key findings include a 30% reduction in CO_2 emissions per package delivered and a 0.65 reduction in truck miles per package delivered. Additionally, the project proved the viability of e-cargo bikes as a replacement for trucks and the potential for greater CO_2 emission reductions through an expanded microhub network. This success was at least partially dependent on its location in a dense urban neighborhood and also the strong partnerships with mobility operators and delivery companies.

Source: Charlotte Schubert, "Experimental Zero-Emissions Last-Mile Delivery Hub Launches in Seattle as a Test for Urban Logistics," GeekWire, June 17, 2021, https://www.geekwire.com/2021/experimental-zero-emissions-last-mile-delivery-hub-launches-seattle-test-urban-logistics/; "The Seattle Neighborhood Delivery Hub Pilot Project: An Evaluation of the Operational Impacts of a Neighborhood Delivery Hub Model on Last-Mile Delivery" (Supply Chain Transportation & Logistics Center, University of Washington Urban Freight Lab, September 2021), https://www.seattleneighborhoodhub.com/_files/ugd/86f1fc_55a01fbac0a34d20b3946aa41eefc16d.pdf.

Case Study: Colibri Mini Hub in Montreal, Canada

In 2019, Montreal partnered with a sustainable mobility nonprofit to establish solutions to reduce emissions and other negative impacts of urban deliveries. After an engagement process with local businesses, restaurants, and courier companies, a list of recommendations was produced. One of the top recommendations was the establishment of a "mini hub," an urban warehouse where trucks deliver packages that would then be delivered by a fleet of e-cargo bikes. A central, city-owned location was needed to serve as the mini hub's site. The city landed on a vacant bus station with a large parking lot in the middle of Montreal's downtown. Several local courier companies agreed to participate in the project and collaborated on replacing existing truck routes with the new mini hub. One large truck would deliver all packages to the mini hub, and then five e-cargo bikes and one small truck would complete all the deliveries from the hub. This new model saw a 15% increase in deliveries while also lowering operating costs. Key to the project's success was that the City permitted the delivery cargo bikes to enter pedestrian zones. Montreal provides an example of how a city may repurpose underutilized land in urban cores to make deliveries more sustainable and efficient.

Source: Barry Lyster, "Montreal's Colibri ECargo Bike Project Is a Rising Star in Mobility Solutions – Ebikes Int'l," EBikes International (blog), April 1, 2021, https://ebikes-international.com/montreals-colibri-ecargo-bike-project-is-a-rising-star-in-sustainable-mobility/.

Off-Hour Delivery

Off-hour delivery (OHD) shifts the delivery of goods from traffic peak period to off hours (typically 7 p.m. to 6 a.m.), thereby increasing the efficiency of goods delivery. An off-hour delivery strategy can offer several benefits for businesses, the community, and the city in general. Off-hour deliveries can potentially significantly reduce overall freight emissions. Evidence from three American cities shows that off-hour deliveries can reduce freight emissions by up to 67%.[18] Off-hour delivery can help alleviate traffic and double-parking problems and improve safety, especially for pedestrians and bicyclists. Additionally, off-hour delivery can lower delivery costs for businesses, offer more certainty about product arrival times, and create a better shopping environment as staff focus primarily on customers rather than delivery since deliveries are being made at times when the stores are not generally open to customers.[19]

Research has shown that a significant portion of freight emissions can be attributed to freight delivery vehicles being caught in congestion.[20] Additionally, in urban areas, freight delivery vehicles often have difficulty locating parking. For example, a case study of Seattle found that cruising (i.e., searching for parking) accounted for 28% of total trip time on average.[21] Any comprehensive urban freight emission reduction plan will need to account for emissions due to congestion and cruising.

Case Study: Off-Hour Deliveries in New York City

In 2009, NYC initiated a pilot OHD program in which 25 receiver businesses and eight carriers participated, receiving financial incentives from the city. Participating businesses and carriers conducted deliveries between 7:00 p.m. and 6:00 a.m. Delivery companies saw vehicle travel times improve by up to 130% in comparison to midday travel speeds, saving an average three hours of time per tour. Drivers reported faster speeds, less congestion, and more available parking. The program was generally very popular with businesses and carriers due to increased efficiency, and later studies also indicated significant emission reductions due to the OHD. One challenge with the OHDs for businesses was having staff available at late hours to receive the deliveries. However, this was solved in some cases with unassisted delivery systems. (e.g., providing a key to drivers, delivery lockers, storage pods, etc.).

Source: Jose Holguin-Veras et al., "Integrative Freight Demand Management in the New York City Metropolitan Area" (United States Department of Transportation, September 30, 2010), https://ohdnyc.com/sites/default/files/business-admin-files/Home/ohd-final-report.pdf.

Case Study: Off-Hour Deliveries in Stockholm, Sweden

In 2014, the City of Stockholm, Sweden partnered with freight companies to allow and encourage deliveries within the city during the off-peak hours of 10:00 p.m. to 6:00 a.m. Prior to this program, Stockholm's regulations completely banned nighttime deliveries due to concerns primarily about noise. The program was voluntary and was meant to be a pilot to explore the potential to expand the practice of off-hour deliveries within the city. The reception of the off-hour delivery pilot was generally positive with truck drivers reporting increased efficiency and shorter delivery times as well as lower environmental impacts. Driving speeds during off hour deliveries were measured to be 31% higher than deliveries during the morning peak. To help mitigate concerns about noise late at night from the delivery vehicles, the City of Stockholm partnered with a company that provides silent systems for distribution, such as rolling cages, to outfit the participating trucks. Ultimately, a study team determined that the benefits of off-peak deliveries outweighed additional costs.

Source: Anna Pernestål Brenden, "Primer for Improved Urban Freight Mobility and Delivery: Operations, Logistics, and Technology Strategies - Off-Hour Delivery - FHWA Office of Operations," U.S. Department of Transportation Federal Highway Administration, July 30, 2018, https://ops.fhwa.dot.gov/publications/fhwahop18020/off_hour_delivery.htm.

Information and Communication Technologies

Freight movement and delivery include multiple phases, such as warehousing, management, and transport,[22] and the operation of these phases can be managed broadly. As new technologies and transportation procedures are introduced, the management of these phases must change to retain productivity. The inefficiencies of last mile-delivery can cause significant emissions release as vehicles cruise and idle, and inefficiencies can exist in all phases. Technology and analytics can help identify these inefficiencies and reorganize freight operation.

Information and Communication Technologies (ICT) are the application of modern tools and systems to implement more efficient data usage and connection. Broadly, ICT has the potential to increase efficiency and decrease delivery times thus significantly reducing freight emissions.[23] Particularly, there are strong potential environmental and efficiency benefits for intermodal freight (rail and road) associated with ICT.[24] Additionally, a study analyzing different freight mobile applications in China identified that utilizing smart phone applications can influence the integration of the distribution enterprise into the market, the connection between users, and the optimization of distribution routes.[25] A strategy of "always laden" trips is emphasized in this application to ensure vehicles are carrying cargo on outgoing and return trips. Co-Loading is another freight delivery strategy that leverages ICT to make deliveries more efficient. Co-loading is the practice of automatically matching loads that have destinations and origins along similar routes.[26] Estimates for greenhouse gas emission reduction through co-loading range from 30% to 40%.[27] There are also potential significant gains in fuel efficiency through the aerodynamic design of both tractors and trailers (which are generally considered separate assets). The fuel efficiency gains require aerodynamic trailers to be paired with compatible tractors. ICT could be utilized to intentionally pair trailers with appropriate tractors, for which the fuel economy gains are estimated to be as high as 13.8%.[28] Through stakeholder engagement, operators should be encouraged to consider and adopt ICT technologies to improve freight movement efficiency and operation, particularly at intermodal stations.

Case Study: European Logistic Service Providers

In 2020, researchers performed a cross-country study to analyze Logistic Service Providers (LSP) in Germany, Italy, and the UK. The service of these organizations was reviewed for ecological practices and technologies. Five categories were identified as fields of operation where LSPs could implement practices and technologies to reduce environmental impacts: transport, warehousing, logistics, management, and supply chain. The emerging technology identified in the research range from GPS applications, real-time locating systems, and supply chain collaborative systems, which have strong potential to improve the efficiency of freight delivery chains. However, LCPs in the study area did not implement these strategies consistently, resulting in an unrealized ecological value, indicating that governments could implement policies and regulations that support adopting green practices and information systems, influencing freight distribution logistic providers.

Source: Piera Centobelli et al., "Evaluating Environmental Sustainability Strategies in Freight Transport and Logistics Industry," *Business Strategy and the Environment* 29, no. 3 (2020): 1563–74, https://doi.org/10.1002/bse.2453.

Case Study: ICT Software at Brussels Airport

In 2018, officials at the Brussels Airport partnered with the data-sharing company Nallian to create an ICT program entitled BRUcloud, a digital app-based system that automatically assigns freight terminal-dock time slots to truckers to improve efficiency, decrease loading times, decrease cargo congestion, and ultimately decrease emissions. The program creates an umbrella platform for all cargo service providers to facilitate the intermodal transfer for cargo from air cargo to truck cargo at the airport. The application provides coordination between all the disparate courier companies operating through the Brussels Airport. Results from the program include significantly lower waiting and idling times for trucks and reduced congestion. The BRUcloud program has proved to be very popular with freight operators due to improved efficiency and communication.

Source: Chris Barnett, "Tech Firms Combating US Airport Congestion" (The Journal of Commerce Online, March 4, 2019), https://www.joc.com/air-cargo/international-air-freight/tech-firms-combating-airport-congestion-through-digitization-data-sharing_20190304.html.

Cargo Bikes

Cargo bikes are manual or electric bicycles specifically designed for transporting goods or passengers. Cargo bikes have existed for a long time, but their popularity has increased recently. The COVID-19 pandemic created a surge in online shopping and on-demand food delivery. Since much of these online purchases have resulted in on-road delivery, traffic, and emissions, many cities have started pilot testing e-cargo bikes to determine the feasibility and effectiveness of these bicycles for last-mile delivery. E-cargo bikes are electric-assist bicycles designed to carry heavier loads:; they have a general payload of up to 770 pounds and can reach maximum speeds of 28 mph. This makes the bikes well-suited as zero emissions last-mile delivery solutions for purposes such as mail and parcel delivery services, restaurant delivery, and retail delivery services.

Case Study: Boston's E-Cargo Bike Pilot Program

When looking to address increased traffic congestion due to a high rate of growth in e-commerce and on-demand delivery services, the City of Boston chose to focus on the delivery of goods and services and their impact on curbside infrastructure demand. The 18-month e-cargo bike pilot program launched in late Summer 2022 with initial funding from clean energy grants and resources from the state's Department of Energy. Community outreach during the development phase of the program included feedback from local and regional transportation agencies, mobility operators, delivery service providers, neighborhood and resident groups, and business improvement districts. Multiple cities have already implemented e-cargo bike programs; however, Boston is approaching the problem with a slightly different solution—a focus on deliveries to and from small businesses. Resulting policies include tax incentives; stipends or direct subsidies to delivery couriers to buy, retrofit, or maintain a personal e-bike, if primarily used for deliveries; incentives for restaurants to offer accessible secure parking; and requiring companies over a certain size or delivery volume to adopt the Mobility Data Specification and report on delivery activity on a continuous basis. Boston expects the e-cargo program to reduce GHG emissions and congestion, while making streets safer for pedestrians, cyclists, and drivers.

Case Study: Seattle Cargo E-Bike Pilot

In 2018, the United Parcel Service (UPS) piloted a one-month cargo e-bike delivery system in Downtown Seattle. UPS utilized electric-assist tricycles with removable cargo boxes that could hold up to 400 pounds of cargo to perform deliveries and pickups. Goods from the Seattle UPS depot were delivered to a parking lot in downtown Seattle, which served as a hub from which the cargo e-bikes completed the final leg of the delivery. The cargo bikes were able to eliminate certain issues related to truck delivery including the need to cruise for parking, dwell times for delivery vehicles, as well as the emissions and congestion caused by delivery vehicles. However, the lower speed and carrying capacity of the cargo e-bikes did result in slower deliveries. The cargo bikes delivered at a rate of about five establishments per hour, approximately 30% of the truck delivery rate in the same study area. Results showed that, over the course of the pilot program, cargo e-bike deliveries became faster and more efficient. This points to the potential for experience gains over time, resulting in greater cargo bike delivery efficiency, if the pilot were to continue.

Source: "Cargo E-Bike Delivery Pilot Test in Seattle" (University of Washington Urban Freight Lab, August 2020), https://depts.washington.edu/sctlctr/sites/default/files/research_pub_files/Cargo-E-Bike-Delivery-Report.pdf.

Zero Emissions Zones

Zero emission zones for freight (ZEZ-Fs) are designated areas in cities where only zero-emission goods delivery vehicles can enter. Such access restrictions can help reduce GHG emissions, improve the livability and health of urban communities, and save businesses money by enhancing freight delivery efficiency.

ZEZ-Fs strategies have been implemented in cities across the globe with different characteristics. For example, the Netherlands implemented a national harmonized approach, which involved 30–40 cities pursuing ZEZ-Fs strategies, while London began operate two pricing zones to regulate all vehicle access based on their emissions: the Ultra-Low Emission Zone, covering Central London, and the city-wide Low Emission Zone. Lastly, Santa Monica (California), is pilot testing a voluntary zero-emissions, last-mile delivery zone.[29]

Case Study: Zero Emission Delivery Zone (ZEDZ) in Santa Monica

In Spring 2020, Santa Monica partnered with the Los Angeles Cleantech Incubator (LACI) to pilot a voluntary zero-emissions delivery zone for up to three years. The pilot program has multiple goals including: (1) developing best practices for zero-emission zones, (2) offering immediate health and environmental benefits to the local community, and (3) providing economic opportunity to small businesses by offering access to zone benefits. The pilot includes both commercial and residential areas and covers one square mile of Santa Monica. There are no restrictions or emissions-based fees for entry into the designated area; instead, partners can learn and participate in the program voluntarily. The pilot program involves the use of e-cargo bikes and other micro-mobility devices as well as light- and medium-duty electric vehicles for last-mile delivery of parcels, food, and furniture. The pilot program also benefits from advanced technologies, such as digital curb management and measurement and tracking solutions for important factors, such as noise and air pollution, traffic, and delivery volumes. Although Santa Monica's ZEDZ program is currently voluntary, LACI has already received many applications for technology and information request, indicating community interest in the program. It is expected that this pilot project will set the stage for a region-wide low emission zone.

Case Study: Central Exclusion Zone in Oslo, Norway

In 2017, Oslo, Norway made a commitment to become carbon neutral by 2030 and began working on actions to accelerate the city's transition to carbon neutrality. A key action was establishing a zero-emission zone in the city center. To do this, a congestion tax was implemented for the city center (called the central exclusion zone) that applies to all vehicles, including freight. However, an exemption was made for zero-emission vehicles to provide an incentive for adopting electric vehicles. Additionally, the city began removing parking spaces in the city center (with special consideration for people with restricted mobility who may need certain parking spaces) while retaining and expanding certain freight loading zones based on demand. The central exclusion zone has resulted in lower VMT in the city, increased adoption of alternative modes of transportation, lower congestion, and accelerated courier companies moving towards alternative fuel sources. Oslo's policies have also sent a strong message to courier companies to plan to operate only zero emission vehicles in the city center in the near future.

Source: "Oslo's Zero-Emission City Center: Innovation and Collaboration," Global Commercial Vehicle Drive to Zero, 2022, http://toolkit.globaldrivetozero.org/case-studies/oslo/.

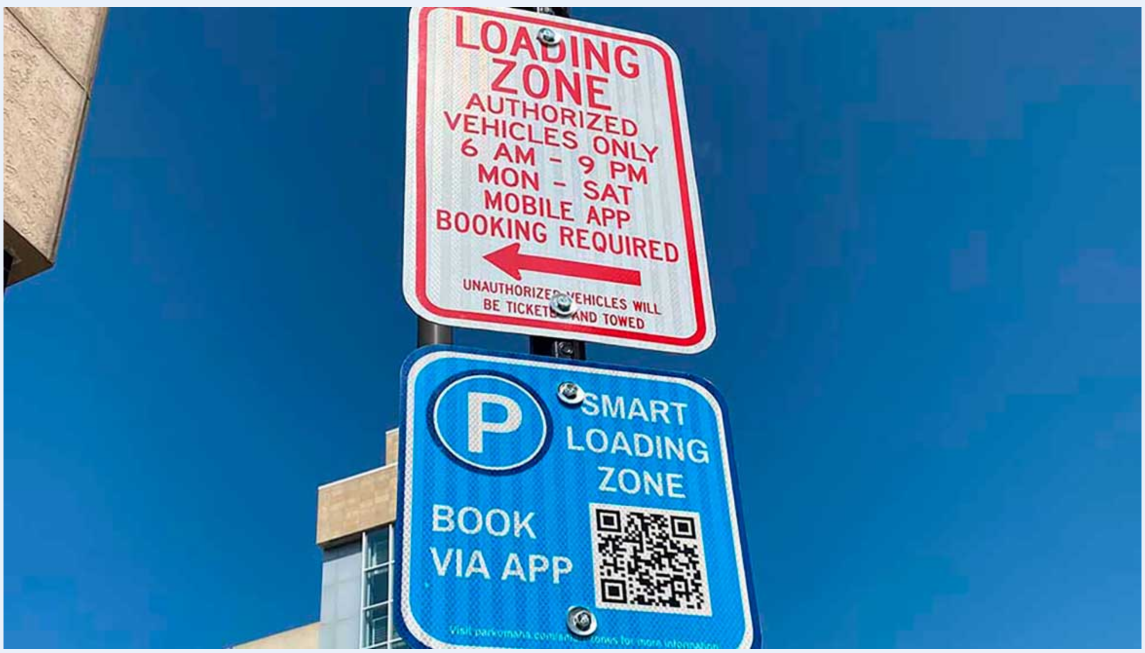
Smart Loading Zones

Smart loading zones are designated loading and unloading areas of a curb lane that authorized drivers can reserve using a smartphone application or other technology.[30] Smart loading zones are used to manage valuable curb space that commercial vehicles compete for. The goal is to improve the coordination, convenience, and safety of curbside delivery in cities. Although smart loading zones generally target commercial delivery fleet and rideshare vehicles, retail and restaurant pickup service drivers can also be included in the program.

Cities world-wide have pilot tested smart loading zones. Examples in the U.S. include Nashville, TN; Omaha, NE; Aspen, CO; and West Palm Beach, FL. International examples include Paris, France; Dublin, Ireland; and Belfast, U.K. Regardless of the locale, smart loading zones offer several common benefits including more efficient use of curb space; reducing illegal parking; improving traffic and safety; and reducing emissions. When users are charged for curb space, smart loading zones can also serve as a revenue source for municipalities. A well-managed curb also improves overall livability of the community and improves customer experience in local businesses.

Case Study: Smart Loading Zone in Aspen, Colorado

In 2020, Aspen partnered with Coord, a curb management platform, to pilot test eight smart zones in its downtown to streamline goods deliveries to restaurants, retailors, and other businesses in a 16-square-block area. Aspen's smart zone pilot program is innovative for several reasons. First, it introduces a new charging model as opposed to the commonly used time-based loading enforcement schemes. The city uses an app to charge fees for the time drivers spend in the smart zones, which encourages efficient use of loading zones. Second, Aspen's smart zones not only include busy curbside loading zones, but also alleys commonly used for deliveries. Lastly, the program was built upon Aspen's previous experience establishing strong collaborations with businesses and stakeholders to develop and implement progressive parking policy. Smart loading zones demonstrate the effectiveness of public-private partnerships and collaboration with local businesses.



Source: Dawn Miller, "The City of Aspen Welcomes Its First Smart Zones," COORD, November 2, 2020, https://www.coord.com/blog/aspen-smart-zone-launch. Image Source: American Planning Association, photograph, March 1, 2021, https://planning.org/planning/2021/winter/manage-the-curb-with-smart-loading-zones/

Alternative Fuel Source

Alternative fuel source policies support the transition from gasoline and diesel to alternative cleaner sources, such as biodiesel, natural gas, or electricity. Alternative fuel source initiatives typically support the production, supply, and distribution of alternative fuels and vehicles by offering incentives, such as tax breaks or rebates, implementing regulations or mandates, purchasing alternative fuel vehicles for government fleets, and research and development programs.

Historically, higher levels of government (i.e., state and federal) have led developments and implemented alternative fuel source initiatives, but local and regional governments play a key role in the success of such initiatives. There are many barriers to the adoption of alternative fuels, such as limited access to electric charging stations, that local governments can help address, such as requiring the installation of electric charging stations at key locations through reach codes. As part of the U.S. Department of Energy's (DOE) Vehicle Technologies Office (VTO), the Clean Cities coalitions program fosters partnerships and funds local projects, helping communities adopt alternative fuels as well as energy-saving strategies. More than 75 local coalitions have formed to lay the foundation for the adoption of alternative fuels and advanced vehicle technologies.[31] By identifying barriers to implementation and examining the readiness of the community to switch to alternative fuels, local and regional governments can accelerate the deployment of alternative fuels.

Case Study: San Diego Regional Alternative Fuel Readiness Plan

In 2016, the San Diego Association of Governments (SANDAG) partnered with the Center for Sustainable Energy to develop the San Diego Regional Alternative Fuel Readiness Plan. The goal was to identify and address barriers to alternative fuel and alternative-fuel infrastructure deployment to help meet regional GHG emissions reduction targets. The San Diego Regional Alternative Coordinating Council, also known as Refuel San Diego, worked with numerous stakeholders, such as local governments, industry partners, and academia to develop the Readiness Plan. The plan goes beyond previous plug-in electric vehicle initiatives to include all alternative fuels and builds upon the Regional Alternative Fuel Assessment project, which helped identify opportunities and gaps in policy, infrastructure, training, and funding within different sectors (e.g., consumers, public agencies, fuel retailers, etc.) in the entire region. The plan examines a wide range of barriers, such as: (1) a lack of public knowledge on alternative fuels; (2) a lack of safety and technical training for emergency personnel and transportation fleet staff; (3) electric grid reliability and peak hours pricing challenges; (4) the need for codes and permitting requirements for alternative fuel station development; (5) limited access for heavy-duty vehicles to fuel stations; and (6) funding challenges. To overcome these barriers, numerous action items are proposed including education on the benefits of alternative fuel sources, supporting developers in determining ideal locations for alternative fueling stations, and exploring methods to convert fleets to alternative fuels. The plan acknowledges that continued efforts are required to ensure that the region can successfully support greater use of alternative fuels.

Source: "San Diego Regional Alternative Fuel Readiness Plan" (San Diego Association of Governments, February 2016), https://www.sandag.org/uploads/projectid/projectid_487_23916.pdf.

Indirect Source Rules

In addition to direct emissions from delivery trucks, freight contributes to indirect emissions associated with cargo handling and additional travel to and from warehouses and shipping centers by vehicles not controlled by the warehouses. Freight warehouses, used for cargo storage and transportation, are one such contributing factor to indirect emissions. Recent pilot programs, such as the South Coast Air Quality Management District's Warehouse Indirect Source Rule (ISR) n Southern California, are targeting indirect freight emissions by creating a points-based system to encourage new and existing warehouses to incorporate pollutant-reducing measures or pay a mitigation fee.

ISRs introduce a way to address indirect sources of emissions associated with freight, furthering the potential for emissions reduction and mitigation beyond direct reduction of emissions from freight vehicles. Additionally, ISRs provide a program that could be applied to existing warehouse buildings, rather than solely focusing on new development projects, which expands the possibilities for emissions reduction.

Case Study: Indirect Source Rules by the South Coast Air Quality Management District

In 2021, the South Coast Air Quality Management District (SCAQMD) adopted the Warehouse Indirect Source Rule (ISR) with the goal of reducing freight-related air pollution. Warehouses are associated with freight-related emissions due to travel and cargo handling. The ISR requires new and existing warehouses greater than 100,000 square feet to reduce NOx and diesel particulate matter (DPM) emissions, or to otherwise reduce exposure of NOx and DDPM emissions in nearby communities. Similar to cap-and-trade GHG mitigation programs, the ISR is a points-based system with an alternative option to pay a mitigation fee. Points are earned by completing actions from a list of options created by the SCAQMD. Examples of points-earning actions include, but are not limited to: using natural gas for vehicles, incorporating solar panels, using near-zero or zero-emissions freight trucks, and incorporating zero-emission charging and fueling infrastructure. If the warehouse operator chooses to forego participation in the points system, they can pay a mitigation fee, which would be used towards incentives for purchasing clean trucks and charging/fueling infrastructure near the warehouse that paid the mitigation fee.

Source: "South Coast AQMD Governing Board Adopts Warehouse Indirect Source Rule," accessed June 10, 2022, http://www.aqmd.gov/home/research/publications/august-september-2021/indirect-source-rule.

Cumulative Impact Ordinances

Pursuant to California Environmental Quality Act (CEQA) requirements, proposed development projects undergoing environmental review in California must include an analysis of the project's cumulative impact—defined as the combined environmental impacts of past, present, and future projects or activities. A wide range of environmental impacts are assessed in the process, including air quality and GHG emissions impact. An analysis of cumulative impacts helps governments account for individually minor but collectively significant environmental impacts that are caused by related projects or activities over a period of time. Outside of California, different U.S. cities are beginning to implement Cumulative Impact Ordinances (CIOs) that require the consideration of combined environmental impacts of projects and activities.

Case Study: Chicago's Cumulative Impact Ordinances

In 2021, the Chicago Environmental Justice Network introduced bill HB 4093, which requires the review of the cumulative impact of air pollution sources as part of the permit process. The bill, aimed at addressing environmental justice, focused primarily on reducing the impact on vulnerable communities that tend to be disproportionately affected by air pollution and GHG emissions. It is anticipated that HB 4093 would increase community engagement and give citizens more power by requiring a formal process for a public forum to be held, allowing people to raise concerns about a proposed project. Further, the bill requires a stricter siting process for proposed warehouse projects that support goods movement, including an analysis of its potential cumulative impact. Although it is too early to examine the impacts of HB 4093, its focus on environmental justice makes it a notable example for the development of CIOs across the nation.

Stakeholder and Community Engagement

In any environmental or community planning process it is important to conduct robust and thoughtful community engagement. Despite perceptions that average citizens are not concerned with freight, evidence points to urban residents being acutely aware of how freight impacts their daily life, in addition to the negative externalities associated with freight movement.[32] This points to a willingness of residents to engage on the issue of freight and support policies that aim to minimize or mitigate the negative impacts of goods movement. However, it is important to note that attitudes towards urban freight can be significantly heterogeneous depending on the urban context and the diversity of impacted communities.[33] Understanding the unique needs and perspectives of impacted communities is a crucial aspect of community engagement. This is particularly true for disenfranchised, low-income, and/or minority populations, who often been overlooked in environmental advocacy and generally bear the brunt of negative impacts from transportation and freight.[34] Additionally, engagement with key stakeholders, such as businesses, freight operators, and environmental advocacy groups, can lead to significant progress in lessening freight delivery's environmental impacts and improving efficiency.[35] Effective community and stakeholder engagement could include community meetings, a freight outreach group, or special freight events. Another approach would be formation of a working group or task force to address freight-related issues that includes community members, technical experts, freight operators, businesses, and other key stakeholders who can collaborate on solutions that meet that needs of all stakeholders while also working towards achieving environmental goals.

Case Study: Freight Quality Partnerships in Reading, UK

Freight Quality Partnerships (FQPs) are partnerships between local authorities, transportation operators, and other interested stakeholders who collaborate to understand freight distribution issues and create solutions to reconcile the need to access goods with environmental concerns. Reading, UK, near London, has grown into a major economic center, and to address the challenges of freight operation as well as environmental concerns, local authorities created an FQP targeting freight operators, retailers, large businesses, environmental organizations, and neighboring municipalities. Since its formation, the Reading FQP has established and communicated preferred truck routes and delivery zones as well as designated areas where trucks are banned or restricted. It has proven a key venue to engage with and gather feedback on freight impact mitigation strategies such as off-hour deliveries, modal shift, reallocating road space, and encouraging alternative fuels.

Source: Collings Simon, "Freight Quality Partnerships Case Studies" (UK Department for Transport, February 2003), http://webarchive.nationalarchives.gov.uk/20100408192644/http://www.dft.gov.uk/pgr/freight/sustainable/coll_freightqualitypartnerships2/freightqualitypartnerships1.pdf.

Designing Streets for Freight: Dedicated Freight Lanes and Complete Streets

Dedicated freight lanes are streets on public roadways that are restricted to commercial trucks. By linking multiple dedicated freight lanes from a source to a destination, a freight corridor is created. Segregating commercial trucks from other traffic allows freight vehicles to move more efficiently, thereby reducing emissions from freight vehicles that would otherwise be trapped in congestion.[36]

Dedicated freight lanes are primarily a regional or state-wide strategy to promote freight mobility, mostly for public highways. However, freight-only lanes have been paired locally with transit-only lanes.[37] Also, freight mobility can be incorporated into the concept of complete streets by designing streets with freight movement in mind where appropriate (e.g., taking into consideration turning radii, land width, freight loading zones, etc.). A complete street is a road designed to be safe and usable for all users.[38] Goods movement can be incorporated into a complete streets vision with appropriate attention and prioritization based on the urban context and surrounding land uses.

Case Study: Designing Streets for Freight in Seattle

Seattle developed a Freight Master Plan (FMP) to address goods movement within the city that calls for the designating of certain streets under a special truck street classification. These truck streets create a network of corridors to improve and preserve commercial transportation activities and access. This means that freight movement is incorporated in complete street design. Additionally, local truck delivery is considered when making street operational decisions. Designing streets with freight movement in mind allows cargo trucks to move more efficiently throughout the city and reduce freight emissions.

Source: "City of Seattle Freight Master Plan."

Green Loading Zones

Green loading zones are reserved curb spaces for zero-emission trucks to make deliveries more efficient and profitable for fleets operating zero-emission vehicles. The aim of green loading zones is to provide a non-financial incentive to freight operators to adopt delivery vehicles with zero emissions while giving the trucks a convenient and legal curb space to load and unload.

While most government incentives for the adoption of a zero-emission fleet are immediate financial benefits, there is an opportunity to provide a non-financial incentive to adopt zero emission vehicles. At little cost to the respective agency, preferential treatment towards practices that align with environmental goals could potentially spur electrification and/or modal shift. A survey of freight operators found that most fleets put high monetary value on guaranteed delivery locations and reduced parking violation fines.[39]

Case Study: Green Loading Zones in New York City

In 2014, NYC adopted green loading zones (GLZs), dedicated curb space to commercial delivery electric vehicles to incentivize greater adoption of electric vehicles in freight trucking within the city. Potential sites were scored based on a variety of factors including market need, neighborhood context, and alignment with city policies. A post-implementation evaluation of the GLZ program found that participating fleets did realize operational savings from use of electric vehicles. However, incremental benefits take a long time to recover the initial cost of electrification. GLZs can be effective in providing additional justification for fleet electrification when combined with other incentives. Additionally, extra amenities such as vehicle charging could be implemented with GLZs to make them more attractive to operators. While GLZs in NYC were considered a success, challenges arose with the competing goals of monetizing curb space and simplifying confusing curbside restrictions.

Source: Adam Luninsky et al., "New York City Green Loading Zones Study" (New York State Department of Transportation, July 1, 2014), https://rosap.ntl.bts.gov/view/dot/28092; Paul Salama et al., "Green Loading Zones to Support Cost-Effective Zero-Emission Commercial Vehicle Operations in New York City," *SAE Technical Paper Series* 2014- (2014), https://doi.org/10.4271/2014-01-2434. Image source: WXY, *Reserve the Curb for Green Loading,* photograph, Urban Design Forum, February 26, 2018, https://urbandesignforum.org/reserve-the-curb-for-green-loading/

Autonomous Delivery Robots

Autonomous delivery robots (ADRs) are automated electric vehicles used to deliver food and other packages to customers without the intervention of a delivery person. These robots have sensors and advanced navigation technology, which enables them to move through streets and sidewalks without bumping into people and objects.

ADRs can offer several economic, environmental, and social benefits. Because last-mile delivery represents a significant portion of freight emissions and costs, ADRs offer a cost-effective solution. Local restaurants and businesses benefit from less expensive delivery costs, and customers can receive fast contactless delivery service. ADRs can also be safer compared to other delivery modes due to their small size and relatively slower speeds and offer better accuracy of delivering packages to the right person through unlock codes and other tracking measures. ADRs can also be used to deliver food, medicine, and other necessities to individuals without access to other transportation while having a reduced impact compared to more traditional automobile delivery.

A recent study examined existing capabilities of ADRs as well as their energy and emissions-reduction potential. These robots are categorized into two function types: Sidewalk Autonomous Delivery Robots (SADRs) and Road Autonomous Delivery Robots (RADRs). Both robot types utilize “motherships,” which can transport multiple ADRs to an area. The research determined that the use of ADRs can significantly reduce energy consumption and emissions in urban areas. Although both types were effective in reducing emissions, different conditions impact ADRs’ use and effectiveness in cities. SADRs were more energy efficient in areas that were denser and deliveries had shorter distances, while RADRs were more effective when service areas were located far from the depot. Although SADRs reduce on-road travel effectively, the use of sidewalks for robot delivery might potentially decrease pedestrian safety and increase sidewalk congestion.[40]

Case Study: Sidewalk Delivery Robots in San José

In 2021, the City of San José partnered with the sidewalk delivery robot company, Kiwibot, to pilot test the use of delivery robots in the city. Two key objectives of the pilot were to gain insight into the community's perceptions about this technology and to understand how delivery robots interact with pedestrians on sidewalks and other public spaces. The City of San José engaged graduate students from San José State University to collect observational, survey, and interview data to examine potential challenges and opportunities of sidewalk delivery robots from various stakeholders and community members. Results from the pilot test indicate that community members are generally curious about delivery robots and are aware of their potential benefits and disadvantages. For more information, please visit:

https://transweb.sjsu.edu/research/2203-Sidewalk-Delivery-Robots

Source: Serena Alexander, "Robots Among Us: An Analysis of Community Perspectives and Reactions toward Sidewalk Delivery Robots in the City of San José" (Mineta Transportation Institute, May 2022), https://transweb.sjsu.edu/research/2203-Sidewalk-Delivery-Robots. Image Source: Albrecht, Chris, Kiwi's Delivery Robots Roll onto the Streets of San Jose, CA, photograph, The Spoon, July 21, 2020, https://thespoon.tech/kiwis-delivery-robots-roll-onto-the-streets-of-san-jose-ca/

Case Study: Autonomous Robot Delivery in Foster City, California

Foster City approved a pilot program with Starship Technologies, Inc. to permit the company's delivery robots to use city sidewalks and streets to deliver goods. The robots delivered DoorDash and Postmates to both residents and businesses within 2–3 miles of a robot docking point. Each robot carries up to 20 pounds of goods and travels up to 10 miles per hour, limited to 4 miles per hour when on a city sidewalk. The robots navigate through a combination of GPS and optical technology used to detect obstacles. Human intervention is still necessary however when crossing intersections. The autonomous delivery robots provide an efficient method of goods delivery for short distances.

Source: "Autonomous Robot Delivery Service Pilot Program Arrives in Foster City," Foster City, accessed June 26, 2022, https://www.fostercity.org/citycouncil/page/autonomous-robot-delivery-service-pilot-program-arrives-foster-city.

4. Analysis and Recommendations

This section is organized into two main parts. The first examines key objectives and several common strategies to reduce GHG emissions from freight, while meeting the needs of the community. For each objective, the authors present a set of strategies based on a synthesis of literature review and case study findings. Strategies are evaluated through a set of criteria: anticipated level of impact on GHG emissions (effectiveness), overall cost, priority and timeline, and administrative feasibility (implementation). The evaluation is based on our analysis of the literature, case studies, geospatial analysis of freight data, and consultation with City of San José professionals. The second part offers a set of recommendations for the City of San José. The authors also recommend that the city establishes a freight taskforce to further examine the potentials and feasibility of each recommendation.

Part I: Key Objectives and Analysis of Freight Strategies

Objective 1: Manage freight demand and address consumer expectations

Addressing freight emissions involves two key challenges: managing freight demand growth and addressing consumer expectations of a fast, free, or low-priced delivery of goods. Freight demand growth means that GHG emissions will continue to increase under a business-as-usual scenario. Higher consumer expectations can lead to low margins, and consequently, a lack of resources for investing in green freight alternatives.[41] Although the City of San José does not have control over all aspects of freight demand management, there are several strategies that the city can incorporate into the freight and climate action plans to address freight demand and associated emissions and help freight service providers meet consumer expectations.

Table 6. Strategies to Manage Freight Demand and Address Consumer Expectations

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
Land use planning to manage freight demand Shorten distances traveled and examine how land-use decisions impact freight nodes and transportation flows and consequently freight demand.	**High**	**High** Land use changes to significantly alter freight demand can be costly to implement for the city. Supply chain restructuring is often costly for companies.	**High** **Long-term**	**Intermediate** The city can incorporate freight impacts into new land use decisions, but restructuring existing supply chain requires a high level of involvement from companies and higher-level governments.
Green choice alternative and community engagement Work with service providers to add a green choice option for consumers and educate the community about the environmental impacts of their online shopping habits.	**Low**	**Low**	**High** **Short-term** Raises community awareness; enabler for the effectiveness of other strategies	**Intermediate** The city can encourage addition or selection of green choice options through education and incentives.
Production, stockholding, and distribution decentralization Encourage local production of goods and food; establish microhubs; and position automated locker boxes near grocery stores, transit stations, or other facilities that people use frequently.	**High**	**Intermediate**	**High** **Long term**	**Intermediate** The city can organize pilot projects with local producers and delivery companies.
Off-peak deliveries as a TDM strategy Encourage or require service providers to make deliveries early morning or during the night. Encourage more companies to accept off-peak delivery.	**Intermediate** Strategies that directly regulate freight operations during peak hours are likely more effective than strategies that encourage off-peak delivery.	**Low** Benefits in transportation efficiency outweigh the cost of policy implementation for the city. For companies, staff cost will increase, but savings from productivity outweigh costs.	**High** **Short term**	**Intermediate** The city can regulate heavy truck operations during traffic peak hours or otherwise encourage off-peak delivery through financial incentives, and public recognition for outstanding service.

Objective 2: Utilize low emissions modes and multimodal solutions for freight

Freight transportation mode plays a key role in its contribution to GHG emissions. There are two major factors that should be considered: (1) the selection of the most appropriate mode of freight transport; and (2) the optimization of multimodal operations. Selection of the most appropriate mode is complex because often one single mode does not meet all important criteria. For example, rail can be environmentally friendly and safe, but not as available, flexible, fast, or efficient as road transport. Combining two or more freight transport modes can help benefit from advantages of several modes, while alleviating their disadvantages to the extent possible. The city can examine the combination and complementarity of various modes to develop strategies to optimize multimodal freight transport.

Table 7. Strategies to Utilize Low Emissions Modes and Multimodal Solutions for Freight

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
Increased use of rail Explore how existing rail infrastructure can be better used to transport goods (and passengers) without additional costs.	**Intermediate** Rail is not available for many delivery locations.	**Low** The cost of implementation is low since the city uses existing rail systems.	**Intermediate** **Long term**	**Low** Requires a high level of commitment from rail orgs., companies, and other govts. The city can conduct an in-depth study of how rail can be better incorporated into the freight system.
Light modes Explore opportunities to use light modes, such as delivery robots, cargo bikes and small electric vehicles, for urban freight delivery.	**High** Lights modes have a potential to significantly reduce GHGs if deployed at a large scale.	**Intermediate** The cost of different light mode options varies, but the city can explore the use of inexpensive options, such as cargo bikes, first.	**High** **Short term** Many cities are currently exploring the use of light mode options for last-mile delivery.	**High** The city can pilot test the feasibility of light modes for last-mile delivery.
Multi-modal optimization Examine different modes and their linkages and optimize transshipment possibilities (e.g., minimize waiting time for trucks and other vehicles).	**Intermediate**	**Intermediate**	**Intermediate** **Long term**	**Low** Requires a high level of commitment from delivery companies, but the city can conduct an in-depth study to identify and address common multi-modal inefficiencies.

Objective 3: Optimize freight assets and environmental resources

Urban freight planning involves strategies to use available freight and environmental resources effectively and efficiently. Strategies to optimize freight assets and environmental resources are sometimes overlooked, but are not insignificant. Because resource optimization strategies typically utilize existing resources, the only cost associated with these strategies is implementation costs.

Table 8. Strategies to Optimize Freight Assets and Environmental Resources

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
Shared city hubs and warehouses Explore the possibility of effectively sharing hubs and warehouses (e.g., use technology tools to ensure optimal use of hubs and warehouses).	**Intermediate**	**Intermediate**	**Intermediate** **Long term**	**Low** Requires a high level of commitment from delivery companies, but the city can partner with companies to pilot test new technologies to optimize the use of physical assets.
Load optimization Encourage freight delivery providers to adjust truck size based on load and use truck space effectively.	**High** Load optimization can significantly reduce GHGs by maximizing loads per truck, and reducing VMT.	**Low**	**High** **Short term**	**Intermediate** Freight companies often find load planning a constant challenge, but the city can partner with local companies to pilot test the use of load planning software that allows operations managers and small business owners plan truck loads and routes without manual calculations.[42]
Curb management Explore and implement various curb management strategies, such as "demand-based parking, time limits, time-of-day restrictions, reduced occupancy targets, provision of off-street options, and priority parking programs."[43]	**High**	**Intermediate**	**High** **Short term** Many cities are currently exploring various curb management strategies to address freight impacts.	**High** The city can manage curb space and on-street parking to help reduce GHG emissions from freight.
Packaging Encourage businesses to use less packaging and products needed to deliver goods (e.g., package redesign, waste reduction, recycling, material substitution, etc.).[44]	**Intermediate**	**Intermediate**	**Intermediate** **Long term**	**Low** By raising consumer awareness about the negative environmental impacts of single-use-packaging, the city can help drive change.
Restricted multi-use lanes Explore the possibility of implementing restricted freight and transit lanes	**High**	**High**	**Intermediate** **Long term**	**High** The city can explore options to optimize existing freight networks

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
(e.g., allow low-emissions freight vehicles in bus or bicycle lanes, restrict freight vehicles to right lane, etc.)[45]				through implementing restricted multi-use lanes.

Objective 4: Focus on the last mile

One key takeaway from this research is that the biggest opportunity for the City of San José to reduce freight emissions is related to the last mile: trucks and vans that transport goods from regional distribution hubs to local businesses or homes. Research on strategies to reduce urban freight emissions overwhelmingly focus on last-mile solutions.

Table 9. Strategies to Address the Last Mile

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
Common carrier lockers (CCL) Pilot test common carrier lockers in the City of San José to allow carriers to drop-off and leave deliveries in one safe and publicly accessible location.[46]	**Low** The strategy only targets parcel delivery trucks, and thus cannot significantly boost turnover at commercial load/unload zones.	**Intermediate**	**Intermediate** **Long term**	**Intermediate** Amazon and UPS have their own branded locker systems, but the city can pilot a CCL in a public space (e.g., Seattle Municipal Tower CCL pilot).[47]
Microhubs Establish a central pick-up and drop-off location to consolidate trips.	**Intermediate** Studies have shown that microhubs can result in fewer polluting trucks entering the city center, and reduced VMT.[48]	**Intermediate**	**High** **Short term**	**High** The city can establish microhubs in urban villages or near popular urban facilities.
Cargo bikes Explore and pilot test the use of various cargo bikes, such as e-bikes (e.g., Seattle's pilot)[49], and temperature-controlled cargo bikes for delivery of perishable items (Netherlands)[50]	**Intermediate** If deployed at a large enough scale, cargo bikes can help reduce GHGs significantly.	**Intermediate**	**High** **Short term**	**High** Many cities pilot tested cargo bikes.
Delivery robots Explore the use of advanced delivery robots	**Intermediate** If deployed at a large enough scale, delivery robots can help reduce GHGs significantly.	**Intermediate**	**High** **Short term**	**High** The city can pilot test advanced sidewalk delivery robots, such as "Starship"[51] robots.

Objective 5: Deploy alternative sources of fuel and energy efficiency measures

Although strategies to advance alternative vehicle fuel and energy efficiency technologies are often pursued by higher levels of government, cities can play an important role in the deployment of alternative fuel freight vehicles and energy efficiency measures.

Table 10. Strategies for Deploying Alternative Fuel Sources and Energy Efficiency

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
Green loading zones Explore the feasibility of dedicated curb space for commercial delivery electric vehicles	**Intermediate** Loading zones reserved exclusively for electric trucks can help accelerate deployment of electric trucks.	**Low**	**Intermediate** **Short term**	**Intermediate** Green loading zones are not common in the U.S. now, but the city can explore the feasibility of green loading zones through a pilot project.
Zero or low-emissions delivery zones Designate specific areas where only zero- or low-emissions goods delivery vehicles can enter (e.g., allow cargo bikes in pedestrian only areas)	**Intermediate**	**Intermediate**	**Intermediate** **Long term**	**Low to Intermediate** The strategy requires a high level of support from community and stakeholders. The city can explore low-emissions delivery zones through a pilot project.
Alternative Fuel Readiness Plan (AFRP) Identify and address barriers to alternative fuel and alternative fuel infrastructure deployment within the city.	**Intermediate**	**Intermediate**	**High** **Short term** The strategy can be an enabler for the success of ZEVs.	**High** The city can work with various stakeholders to develop an AFRP.
Financial incentives for green freight and efficiency measures Explore feebates, subsidies or regulations to encourage the use of alternative fuel vehicles, environmentally friendly options, or freight efficiency practices (e.g., minimizing empty miles).	**High**	**Intermediate to High (flexible)**	**High** **Short-term**	**High** The city can work with freight companies to identify the most effective incentive programs.

Objective 6: Engage the stakeholders and explore collaboration opportunities

Effective community and stakeholder engagement practices can help the City of San José collect and analyze crucial information and boost the chance of effective freight strategy implementation.

Through a meaningful engagement process, the City can examine how freight and emissions reduction strategies impact local communities and other stakeholders. Also, stakeholders can provide a chance to understand challenges and opportunities related to green freight strategies. Engaging communities and other stakeholders early in the planning process can also help achieve community buy-in to increase the chance of successful freight strategy implementation.

Table 11. Strategies to Engage Stakeholders and Collaborate

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
Establish a freight outreach group and/or a task force Form or use existing outreach groups and task forces to receive input from key stakeholders and community members.	**Low**	**Intermediate**	**High** **Short term**	**High** The city can utilize the freight stakeholder network developed through this project.
Equity discussions Collect and analyze geospatial data and community input to better integrate equity into freight and climate planning processes.	**Low**	**Low**	**High** **Short term**	**High** The city can partner with community orgs. and SJSU to initiate/continue equity discussions.
Special freight events and workshops Engage the community by organizing green freight events and workshops.	**Low**	**Intermediate**	**Intermediate** **Long term**	**High**
Public-private collaboration on green freight technology development and innovative pilots Partner with technology companies and freight carriers to test new technologies and innovative freight solutions.	**Intermediate**	**Intermediate**	**High** **Short term**	**High**
Collaboration with other governmental agencies Explore opportunities to collaborate with other cities within the region, regional organizations, and state agencies focusing on freight emissions.	**Intermediate**	**Low**	**High** **Long term**	**High**
Partner with universities and engage experts in freight and climate planning processes Establish partnerships with universities to expand upon freight research conducted for this project (e.g., in-depth case study analysis).	**Low**	**Low**	**High**	**High**

Objective 7: Develop a data sharing platform

One challenge to transforming the urban freight system is limited data transparency in the logistics chain and difficulties obtaining accurate and reliable freight data.[52] Freight carriers and companies producing or selling goods might be reluctant to share data with the City. Also, measuring freight traffic separate from passenger transport using GPS data is difficult. Without sufficient high-quality data, it is practically impossible to diagnose the problem or examine its distributional impacts correctly. This can significantly hinder the development and implementation of effective and equitable freight and climate-planning strategies.

Table 12. Strategies for Data Sharing and the Use of Big Data

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
Protocols for data sharing Consider developing standard protocols to facilitate data sharing between companies and the city.	**Low**	**Low**	**High** **Short term** The strategy can be an enabler for the effectiveness of data sharing platform.	**High** The city can develop a set of guidelines for data sharing.
Public interactive cost-benefit analysis tools Engage the public by developing an interactive cost-benefit analysis tool to explore the emissions impact of goods delivery and their online shopping habits.	**Low**	**Low**	**Low** **Short term**	**High** The city can develop an interactive tool to help the community understand and examine the economic, environmental and social costs and benefits associated with their shopping habits and delivery preferences (e.g., carbon footprint tools).
Information and Communication Technology (ICT) system Encourage local freight companies to develop an ICT system to help improve logistics and fleet management.	**Intermediate** Research suggests that more sophisticated ICT systems can help cancel out the negative impacts of e-commerce on road transportation.[53]	**Intermediate**	**Intermediate** **Short term**	**Intermediate** This strategy requires a high level of involvement from companies and higher-level governments.
Data sharing platform to encourage green procurement practices Explore the feasibility of creating a secure data sharing platform where companies can share information about their green procurement practices with each other and the	**Intermediate**	**Intermediate**	**High** Data availability and transparency in the logistics chain is a key factor for the development	**Intermediate** Companies can be reluctant to share data with the city or their competitors. The city can use the data to develop

Strategy & Description	Anticipated Level of Impact on GHGs	Cost	Priority & Timeline	Administrative Feasibility & the City's Role
city.[54] Companies will only have access to the platform, if they first share their own data.			and implementation of freight strategies. **Short term**	guidelines to help businesses select products, services and processes based on their impact on the environment.

Part II: Recommendations for the City of San José

Although the City of San José can explore the feasibility of all strategies analyzed in Part I through stakeholder feedback and in-depth analyses, there are a few strategies that the authors would like to emphasize in this section. The authors believe that the strategies listed in this section are readily implementable or have the potential to guide the city's future climate and freight planning efforts.

1) **Examine opportunities to better integrate freight into municipal plans:** Although Climate Smart San José does briefly mention the need to move commercial goods through the city "more efficiently with new technology and fleet management practices,"[55] freight is not emphasized enough in the city's current climate action plan (CAP). Freight strategies in the city's CAP to reduce GHG emissions should be commensurate to its contribution to total emissions. Another opportunity is to develop a freight-specific plan that the city's CAP or plans can refer to in relevant sections. Developing an Alternative Fuel Readiness Plan (AFRP) to identify and address barriers to alternative fuel and alternative fuel infrastructure deployment within the city is another option. Lastly, the City can explore opportunities to better integrate freight into land use decisions and the permitting of new developments with potential freight impacts.

2) **Explore a range of curb-management strategies to utilize curb space efficiently and minimize the environmental, economic, and safety impacts of competing needs:** Freight has not been emphasized in the City of San José's curbside management strategy.[56] The City can identify locations and businesses with frequent freight deliveries that use the curb space and work with business owners to develop curb management strategies. For example, the City can encourage off-street loading, designate storefront curb space as flex zones for deliveries during certain times of the day, and review innovative technologies that support flexible curb management.

3) **Pilot last mile strategies to address freight emissions and scale up the strategies that prove effective:** Several last-mile strategies emphasized in this paper (i.e., common carrier lockers,

microhubs, cargo bikes, and delivery robots) present a great opportunity to curb freight emissions within San José. Pilot testing last mile alternatives can inexpensively reveal unique opportunities and challenges that the City should consider before scaling up these strategies.

4) **Consider adopting restricted multi-use lane strategies to address urban freight challenges:** Although studies indicate that restricted multi-use lane strategies can effectively address freight challenges, these are considered context sensitive. The City can test the viability and effectiveness of restricted multiuse lane strategies, such as allowing low-emissions freight vehicles in bus or bicycle lanes and restricting freight vehicles to the right lane through pilot projects. This will help evaluate the performance, utilization, and political viability of various restricted multi-use lane strategies within the city.

5) **Work with freight companies and local business community to identify and adopt strategies to accelerate the deployment of zero or low-emissions vehicles or the use of other environmentally friendly options:** The City can conduct interviews or focus groups with freight companies and local business community to identify incentive programs for green freight and efficiency measures. A better understanding of what motivates businesses to adopt these measures can help develop effective incentive programs. Some options to explore include green loading zones, low-emissions delivery zones, feebates, subsidies, and/or other regulations to encourage the use of alternative fuel vehicles, freight efficiency practices, or other environmentally friendly options.

6) **Consider adopting strategies to help reduce GHG emissions from freight hubs and warehouses within the city:** San José should not ignore emissions associated with warehousing activities and transshipment processes at freight hubs and warehouses. The most readily implementable options in this category involve the use of technology tools to ensure optimal use of hubs and warehouses and offering incentives for green warehousing and logistics optimization strategies.

7) **Establish a formal partnership bringing together freight companies and the local business community, academic researchers, and city freight professionals:** This project set the foundation for establishing a formal partnership bringing together freight experts from public, private, and academic organizations. The research and stakeholder process revealed several innovative freight strategies but also many new questions requiring further investigation. A "City of San José Freight Lab" can support freight professionals to collect and analyze goods movement data, develop strategies to address freight challenges, and pilot test those strategies within the City of San José.

Endnotes

[1] "2016 Freight Quick Facts Report: Impacts and Performance," Federal Highway Administration Freight Management and Operations, April 23, 2020, https://ops.fhwa.dot.gov/publications/fhwahop16083/ch2.htm.

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Dr. Alexander has worked with many multidisciplinary teams and aims at bridging the gap between technical knowledge, policy decisions and community values. Before joining the SJSU faculty, she conducted community economic development and environmental policy research at the Center for Economic Development and the Great Lakes Environmental Finance Center at Cleveland State University, where she also received her doctorate in Urban Studies (Specialization in Urban Policy and Development). She holds master's degrees in Urban and Regional Planning from California State Polytechnic University, Pomona, and Architecture from Azad University of Tehran.

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